IN TWO SECTIONS—SECTION I

ELECTRICAL ENGINEERING

JANUARY 1950

9

WINTER GENERAL MEETING, NEW YORK, N. Y., JANUARY 30–FEBRUARY 3, 1950

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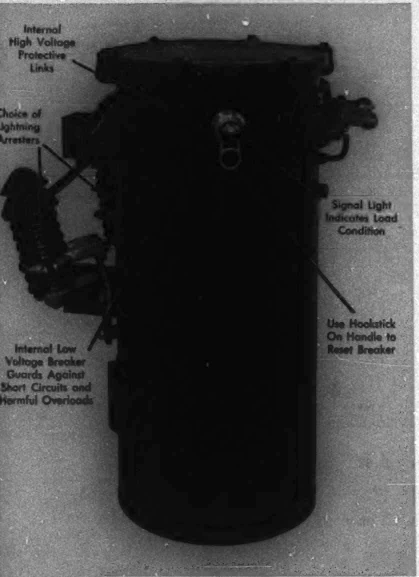
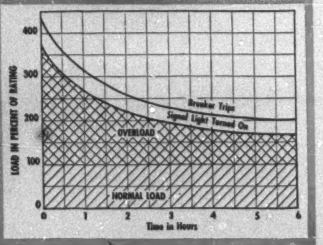

Internal High Voltage Protective Links
Choice of Lightning Arresters
Signal Light Indicates Load Condition
Use Hookstick On Handle to Reset Breaker
Internal Low Voltage Breaker Guards Against Short Circuits and Harmful Overloads



Useful capacity of ACP transformer is increased with secondary breaker, actuated by either or both load current and oil temperature.

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Transformers Give You . . .

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JANUARY

1950

◆

The Cover: Night view of the new Sewaren Generating Station of the Public Service Electric and Gas Company which will be visited during the 1950 Winter General Meeting (*pp* 72–8).

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HIGHLIGHTS........

1949 Index. The 1949 Index to *Electrical Engineering* is being distributed with this issue as Section 2. It is subdivided into subject, author, AIEE and non-AIEE news, and biographical indexes.

1949 Engineering Developments. At the close of each year, we pause to consider and evaluate the many achievements and developments that the past 12 months have seen in the field of electrical engineering. In this issue a picture survey reflecting some of the year's significant engineering developments is presented, as in previous January issues (*pages 12–23*). In addition, this year a number of the AIEE technical committees review various outstanding engineering developments of 1949 that fall within their particular scopes (*pages 1–11, 24–5*).

Winter General Meeting. With plans for a technical program which will top even last year's record program in scope and number of sessions, the 1950 Winter General Meeting will be held January 30–February 3 at the Hotel Statler, New York, N. Y. The schedule of inspection trips for the meeting is a most interesting one, including Sewaren Generating Station, United States Signal Corps Engineering Laboratories, the American Telephone and Telegraph Company, and the *S. S. America* (*pages 72–3, 77–8*). The tentative technical program for the meeting is included (*pages 74–7*).

Conference on Electronic Instrumentation. The second joint AIEE/IRE Conference on Electronic Instrumentation in Nucleonics and Medicine attracted more than 750 persons to the Hotel Commodore in New York, N. Y., October 31, November 1–2, 1949, for three days of highly interesting sessions and an exhibit of commercially available nucleonic instruments (*pages 78–9*). In response to popular demand, it is planned to publish the papers and discussions in pamphlet form. Short authors' digests of most of these conference papers appear in this issue (*pages 68–71*).

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Electrical Essays. J. Slepian's Alter Ego again is puzzled, this time on the subject of electromagnetic waves on wires, and his quandary provides another interesting electrical essay for the entertainment of readers of *Electrical Engineering*. Also included is a short but intriguing essay entitled "A Transformer," by A. A. Kroneberg (*pages 50–1*).

Honors. Two AIEE medals are scheduled for presentation during the coming 1950 Winter General Meeting in New York, N. Y. Dr. Karl B. McEachron has been named recipient of the Edison Medal for his work in the field of lightning research and high-voltage investigation (*page 80*). Details of Dr. McEachron's career are included (*page 83*). The Hoover Medal, which was awarded to Dr. Frank B. Jewett in recognition of his long and illustrious career, will be presented posthumously (*page 80*). Dr. Jewett died on November 18, 1949 (*page 86*).

Board of Directors Meets. Another regular meeting of the AIEE Board of Directors was held recently, this time in conjunction with the Fall General Meeting in Cincinnati, Ohio, October 17–21, 1949. Among other actions taken at the meeting, dates for the 1951 Winter General Meeting were moved back to January 22–26, and organization of a Student Branch at Howard University, Washington, D. C., was authorized (*pages 79–80*).

Electric Fishes. Although electricity itself had not yet been recognized, even the peoples of the ancient world detected a peculiar characteristic in certain fishes and, in fact, utilized this characteristic (shock) in the treatment of various illnesses such as gout and epilepsy. A discussion of these electric fishes, with emphasis on the most potent of them, the electric eel, is presented by the curator and aquarist at the New York Aquarium (*pages 47–50*).

Transistors. Part 4 in a series of articles on semiconductors and the transistor discusses recent advances in the theory of transistor action, circuit performance, and potential applications of transistors (*pages 58–64*).

Design Problems. Engineering courses given to seniors should be designed "to help bridge the gap between college experience and industrial experience—should emphasize the breadth of practical engineering problems." Although not directly applicable for undergraduate assignments, the inclusion of design problems, such as the typical industrial design problems presented in this article, in senior courses should be of great value as a preparation for a job in industry (*pages 29–33*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jun '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Dec '48, p 35A	Midwest General Southern District
Apr '49, p 25A	Winter General (1949)
Jul '49, p 47A	South West District Summer General
Nov '49, p 51A	Pacific General Fall General

Stability in the Swedish Transmission System. Because of the large transmission distances of the existing 220-kv and the future 380-kv systems in Sweden, stability is the principal limitation for loading the lines. To increase the transmission capability a series capacitor is being installed in one of the 220-kv lines. Further, double conductors have been chosen for two new 220-kv lines nearing completion as well as for the 380-kv line now under construction (*page 53–7*).

Relation of Plant Design to Reserve Capacity. The trend toward single boiler–single turbogenerator units is discussed in this article. The economy of installation and operation is compared with the more expensive, more versatile setups with common steam headers. For an adequate reserve system the more expensive often proves more practical than the less expensive one (*pages 64–7*).

Permanent Magnet Alloys. Until recently it was suspected that the working and hardening of steel were responsible for residual stresses in the material. In Dr. Alfred Geisler's report, he discusses the effects of composition and heat treatment on the properties of magnetic materials (*pages 37–44*).

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Total Therm. Res. to Copper Loss (C watts/ft.)	4.44	4.95
Temp. Rise from Dielectric Loss (C)	1.9	2.1
Allowable Rise for Copper Loss (C)	59.1	58.9
Allowable Watts per ft. cable	4.44	3.96
Allowable Current—(Amps. per cdr.)	386.	365.
Allowable Current—(Relative %)	105.6	100.

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"KORDUCT"—for encasement in concrete

"CONDUIT"—for use exposed and underground without encasement

QUESTIONS LIKE THESE

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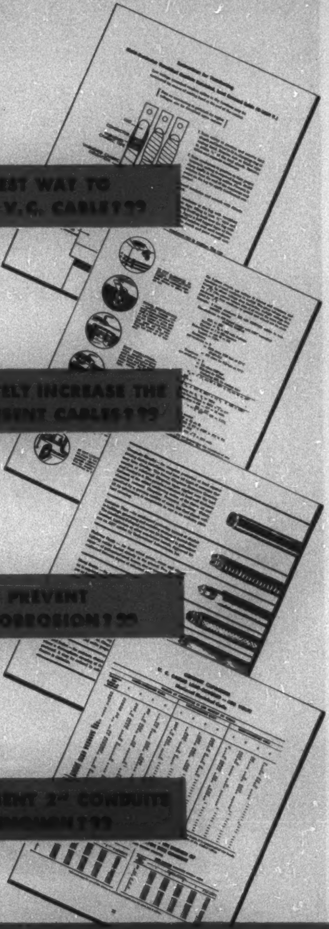

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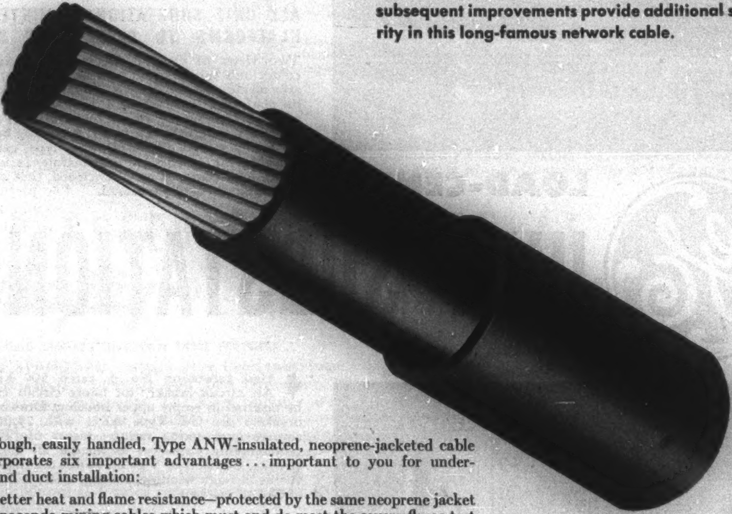

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Two views of General Electric 1000-kva load-center unit substation at new Maytag plant. Valuable manufacturing space is saved by locating units on platforms under the roof, right over the center of the load area. Air switch on primary is easy to operate, contacts are easy to see. Air circuit breakers on secondary are of the drawout type, easily removable for inspection and maintenance. Note entire load center is metal enclosed, thus offering operating safety to personnel.

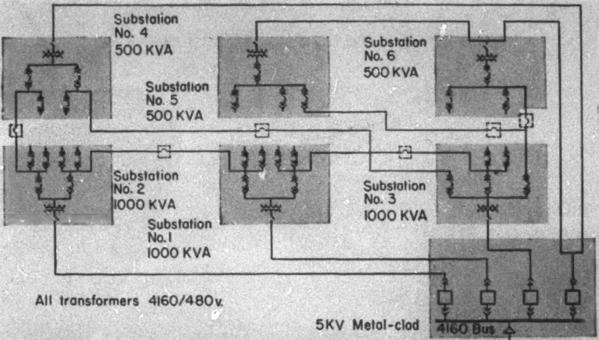
LOAD-CENTER

UNIT SUBSTATIONS

◀ Unit substation No. 5, rated 500 kva. Air circuit breaker for future circuit can be inserted in empty upper housing. Drawout breakers are G-E Type AK-1 with 25,000 ampere interrupting rating—plenty of "IC" (Interrupting Capacity) to handle all short circuits. Contacts of 5 kv air switch are clearly visible through window, another safety feature of G-E substations.

G-E 5-kv metal-clad switchgear handles 4160 volts incoming power, distributes it to six load-center unit substations where it is stepped down to 480 volts for utilization. Metal-clad switchgear is neat in appearance, saving in space, and offers safety to operating personnel. Additional sections can be added for future expansion with a minimum of bother and expense. ▼

CONTINUOUS POWER ASSURED MAYTAG BY SECONDARY-SELECTIVE DISTRIBUTION SYSTEM



This secondary-selective system at the new Maytag installation uses General Electric metal-clad switchgear to handle the incoming 4160 volts through four magne-blast power circuit breakers. Feeders distribute the 4160-volt power to six G-E load-center unit susbstations throughout the building where the high-voltage is stepped down to 480 volts for utilization—right at the center of the load area. This eliminates long, costly secondary feeders. Air switches on the primary of all load centers are rated 5 kv. Key interlocks give operating safety to personnel by preventing breaking of the load current with the air switch, or paralleling transformers.

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INVESTIGATE TODAY how General Electric unit substations can be used in your plant for efficient, flexible power distribution. Contact your G-E sales representative for further information, and write today for the helpful bulletins listed below. *Apparatus Department, General Electric Company, Schenectady 5, New York.*

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GEA-3758	Load-center Power Distribution
GEA-3083	Metal-clad Switchgear
GEA-4057	Interlocked-armor Cable for Primary Circuits
GEA-4352	Flamenol Cable for Secondary Circuits

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The Maytag Co., Newton, Iowa

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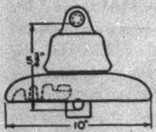
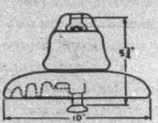


No. 800
Clevis type



No. 900
Ball and socket type

VICTOR No.		800 and 900
60 cycle dry flashover	KV	80
60 cycle wet flashover	KV	50
Pos. impulse flashover	KV	125
Neg. impulse flashover	KV	130
Dry arcing distance	In.	7¾
Leakage distance	In.	11½
Impact rating	In. Lbs.	55
M and E strength	Lbs.	15000

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LEVEL
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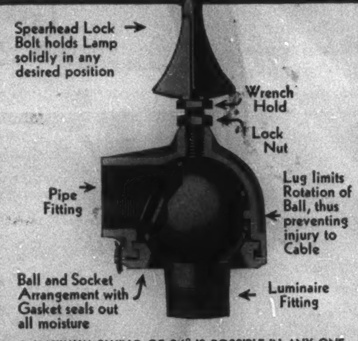
HUBBARD LEVELITE

The Hubbard LEVELITE has been designed to provide a much needed flexibility on street lighting installations. Luminaires may be leveled or purposely tilted in any direction, and permanently locked in that position. Many problems in lighting can be solved by this fixture. Poles which are set some distance in from the curb might require a tilt away from the pole to throw more illumination to the roadway. Special conditions such as building obstructions, landscaping, consisting of trees which it is preferred not to trim, and instances where unforeseen changes occur after lines are in service can usually be handled in a practical manner by LEVELITE flexibility.

Mechanical working of the Hubbard LEVELITE is explained by the illustration at the right. A ball and socket movement is used, effectively sealed by a lead gasket. Rigid setting in position is maintained by a single "spearhead" bolt and lock nut. Changes may be made easily and quickly before, during or after installation.

A most popular combination is the HUBBARD LEVELITE and the new HUBBARD UPSWEEP Street Lighting Brackets. Write for a copy of the Hubbard Linebuilder describing these Brackets if you have not already received a copy.


Spearhead Lock Bolt holds Lamp solidly in any desired position
Wrench Hold
Lock Nut
Pipe Fitting
Lug limits Rotation of Ball, thus preventing injury to Cable
Ball and Socket Arrangement with Gasket seals out all moisture
Luminaire Fitting

A MAXIMUM SWING OF 34° IS POSSIBLE IN ANY ONE DIRECTION, 17° IN ANY DIRECTION FROM THE VERTICAL, OR CENTER LINE OF THE LEVELITE.

Stock No.	For Pipe Arm Nominal Size—Inches	Luminaire Attachment Thread—Inches	Approximate Shipping Wt., Lbs., 100 Pcs.
3279	1¼	1¼ (pipe)	563
3281	2	1¼ (pipe)	900
3282	2	2 (pipe)	944

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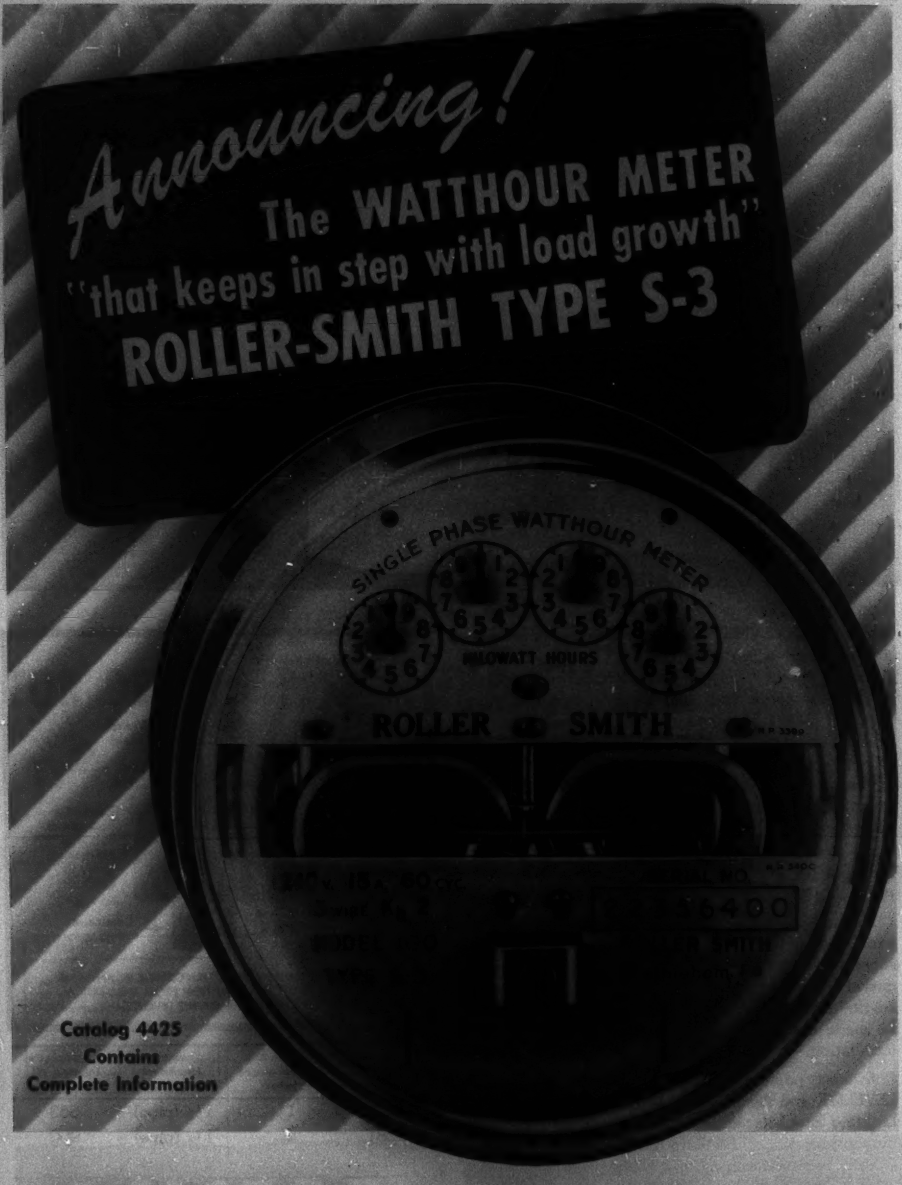
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1949 Engineering Developments

Reviewed by AIEE Technical Committees

DURING the year 1949, important engineering developments have taken place in each of five broad fields of Institute activity: communication, science and electronics, power, general applications, and industry. In the field of communication, the television network has been extended and more than 100 television stations soon will be in operation. Development of color television has continued and two basically different systems have been demonstrated before the Federal Communications Commission with a third system scheduled for demonstration early in 1950. In the field of science and electronics, the application of computing devices of all sizes to business procedures has received increased attention. The emergence of the concept of "information theory" as a means of extending and rationalizing the limiting boundaries of measurement and communication by the use of statistical theory marks a milestone of progress. In the field of power, an all-time peak of installed generating capacity totalling 6,929,201 kw during the year has been achieved. The General Electric Company opened a new high-voltage laboratory at Pittsfield with many refinements for the controlled testing of high-voltage apparatus under various conditions. Research and investigation of power transmission at higher voltages continues at the Tidd experimental station which is a co-operative effort of the American Gas and Electric Service Corporation, and eight other electrical manufacturers. In the field of industry, new arc and resistance welding techniques have found widescale adoption. More precise and compact controls have been developed and applied to a variety of specialized machines. In the field of general applications, definite trends in domestic appliances have been recorded and many significant developments in the production and application of light have taken place, as well as noteworthy experiments in railway motive power. Some of these 1949 engineering developments and a few others are reviewed by the AIEE technical committees.

Communication

AURAL BROADCASTING SYSTEMS

Aural broadcasting has been relatively stabilized so far as outstanding developments are concerned for some time but new stations in the amplitude-modulation field still spring up. The Federal Communications Commission requirements for protection of coverage of existing stations, however, necessitates relatively complex antenna systems. As a result, most of the new amplitude-modulation stations installed, instead of having a single tower as a vertical radiator, require relatively complex arrangements. One station installed during the year, *WDGY* of Minneapolis, Minn., employs nine separate towers in its antenna system with switching arrangements to provide for a different antenna pattern in the daylight hours than that during the nighttime. Switching and readjustment of the antenna phasing is accomplished remotely through motor drives.

While in European countries dry-disk type rectifiers, as contrasted to vacuum-tube or gas-filled rectifiers, have been used for many years in radiobroadcasting equipment, the past year has seen the installation of the first 50-kw amplitude-modulation station in the United States with all of the direct current including the high-voltage supply secured through the use of selenium rectifiers.

In the field of frequency-modulation receiver development is work reported on a gated-beam tube used as a frequency-modulation detector.

RADIO COMMUNICATIONS SYSTEMS

Radio Communication. Mobile radio in the very-high-frequency band has expanded very rapidly within recent years. Heretofore, alternate channels in one area have been reserved as guard bands. With the development of equipment having sufficient selectivity to permit adjacent channel operation, the possible use of the band from 162 to 174 megacycles is nearly doubled in active areas.

Single-side-band radiotelephone equipment was used for the first time in marine service when the British ship *Caronia* made her maiden voyage to New York. (See *Electrical Communication*, June 1949.)

Microwave radio relay systems have been installed to interconnect more than a dozen cities, the principal service presently being for television programs. The network of radio relay stations in the Bell system was extended more than $2^1/_2$ times during 1949 to more than 8,000 channel miles. In addition to the microwave radio links which are inserted in the telephone network, others have been installed or are being planned for the communication networks associated with pipe lines, electric power distribution, and television program pickup.

Air-borne Course-Line Computer. The course-line computer enables aircraft to fly directly to any destination which is within radio range of special ground radio facilities, or to reach the destination by approaching it from any desired direction. The ground facilities consist of Distance-Measuring-Equipment (DME) and Omnirange which determine the origin of a polar co-ordinate system. The co-ordinates of the destination, and the course to be flown, are fed as data into the computer which also receives continuous information of the location of the aircraft with respect to the origin by means of an air-borne DME and a navigational receiver or automatic direction finder. From these data the computer determines the deviation of

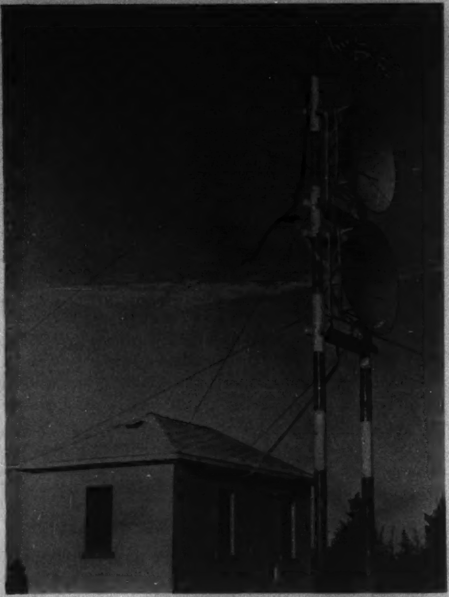

Figure 1. Prince Edward Island pulse time modulation telephone microwave link

the aircraft from the desired course and the distance to the destination. (Photo in pictorial section.)

Microwave Link. Federal Telecommunication Laboratories, Inc., an International Telephone and Telegraph Company associate, has installed a 47-mile commercial microwave pulse time modulation link between the central offices of the Maritime Telephone and Telegraph Company in Nova Scotia, Canada, and the Island Telephone Company, Prince Edward Island, Canada. The operating frequency of the link equipment is 2,000 megacycles. The system handles 13 telephone channels and one special channel for transmission of broadcast programs. It is capable of expansion to take care of 23 telephone channels.

The new link supplements the facilities of the existing submarine cables to Prince Edward Island and affords protection against service outages due to damage of the cables caused by spring ice jams in the straits. In addition to these advantages the link obviates the need for maintenance and repair of an underwater cable, provides many more traffic circuits, and costs considerably less than the installation price of a 3-pair submarine cable.

The operation of the link, which has proved satisfactory, is an example of the ease with which time division multiplex, as used in pulse time modulation, can be incorporated in commercial transmission networks to provide low initial operating costs, large circuit capacity, and great flexibility.

The link equipment consists of a modulator unit and transmitter at the sending end, and superheterodyne receiver and demodulator at the receiving end. Operation of the link is monitored by two alarm circuits at each terminal.

TELEGRAPH SYSTEMS

The most significant technical development in the handling of telegrams during the year was the widespread application of reperforators as signal storage devices for the automatic relaying of complete messages. In commercial telegraphy, the American intercity circuit network has been rearranged so that wires from all tributary telegraph offices in each of 15 areas, like New England, converge on an area reperforator office, like Boston, Mass.

A typical telegram is transcribed manually by an operator into perforated-tape form only at its point of origin, say Lowell, Mass.; thereafter its progression towards its destination, say Lansing, Mich., is accomplished without further manual transcription. Reperforators automatically prepare identical tapes at Boston and at Detroit, the area office for all Michigan. At Boston the tape is switched to the Detroit circuit by 2-letter control signals initiated at Lowell. At Detroit an employee merely pushes a button marked Lansing to switch the tape to circuit of destination.

If the message, instead of going from Lowell to Lansing, is going to Berkeley, Calif., Boston's switch, under Lowell's control, directs the message to the California area office at Oakland instead of to Detroit, and Oakland pushes the Berkeley button. If the message is a cablegram for England, Lowell's control signal can be used to select the Philadelphia office through Boston; the Philadelphia operator pushes a button marked London and thus puts the message directly into that city by cable. If it is a radiogram, Philadelphia's pushbutton selects the appropriate radiotelegraph office in New York, where another reperforator may put the message on the air for receipt in the specified country of destination.

Reperforators are also being used by the wire communication companies for establishing private intercity telegraph networks. Manufacturing concerns, air lines, banks, press associations, and Government departments are some of the users. Recent systems employ fully automatic 2-letter control switching from branch offices or business departments at point of origin to the same at destination. To meet users' needs for handling a large volume of messages to be printed simultaneously at selected points on private wire networks, substantial progress has been made in the automatic switching of multiple-address messages.

Other significant developments in telegraphy must be referred to topically because of space limitations: a non-optical pickup for the handling of telegrams in facsimile, involving the installation of hundreds of units in numerous cities; replacement of time-division multiplex by start-stop printing telegraphs on United States land lines, and use by the telegraph company of its frequency-modulated carriers over telephone company voice and telegraph bands; use of electronic repeaters to replace electromechanical relays; experimental use of intercity radio beams to determine economic operating relationships with open wire lines and multiconductor and coaxial cables.

In the laboratories: study of the new pulsing systems of transmission, especially pulse amplitude modulation having characteristics stable enough for telegraphy; facsimile systems using television techniques for higher speeds; application to facsimile telegraphy of printing techniques based upon discrete-area arrays of static charges; development of new electronic devices for use in telegraph repeater offices for interconnecting intercity lines and subscribers' loops and for accomplishing many of the required supervisory, testing, and transmission-measuring functions; development of carrier telegraph systems for use on short-haul circuits, in view of the increasing scarcity of d-c circuits for such use.

The United States Government for the first time recently signified its adherence, at Paris, to the Telecommunications Regulations. This involves eventual technological compliances in the way of standardized keyboards, apparatus, and operating routines, looking forward to overseas connection between American and European telegraph systems and networks.

TELEVISION BROADCASTING SYSTEMS

By the end of 1949 approximately 100 television stations will be in operation, and construction of 12 more are to be completed. Authorization for additional stations on the present 12 very-high-frequency channels has been frozen by the FCC until a decision is reached on proposed allocation standards involving: the spacing and other factors necessary to reduce interference between stations due to tropospheric propagation in the present very-high-frequency band; the use of additional frequencies between 475 and 890 megacycles; and the status of color television. A hearing before the FCC on these matters has been under way since September and color television has been the only item yet considered. Two basically different systems for color television (field sequential and dot sequential) were demonstrated during the hearing, with a third system (line sequential) scheduled for demonstration early in 1950.

The television receiver field has seen the widespread adoption of built-in antennas. The picture size emphasis has rapidly changed from a 10-inch tube to the 12.5-inch tube which is now the leader in popularity with a definite trend to even larger size, such as the 16-inch tube which is in common use and 19- or 20-inch tubes which were introduced in larger quantities near the end of the year. Large-scale reductions in receiver prices occurred near the middle of the year as manufacturers introduced new models.

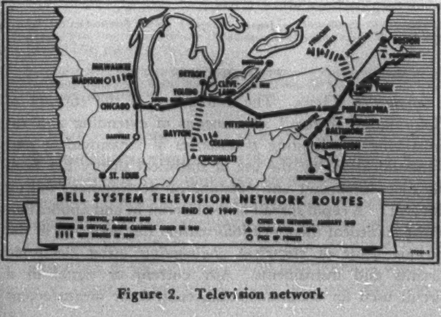

Figure 2. Television network

General design improvements have continued in studio and transmitting equipment with development work looking toward increased power operation on very-high-frequency and transmitters for ultrahigh frequency. Transmitting antennas with power gains up to 20 : 1 over an isotropic dipole have been disclosed. Directional arrays have been made available for those locations in which special considerations warrant their use.

WIRE COMMUNICATIONS

The most significant development in wire communications for the past year has been the extension of television networks over the northeastern and midwestern parts of the United States. On January 11, 1949, the eastern and midwestern television networks were connected together. These networks have been extended since and the present network, with planned extensions during 1949, is shown on Figure 2. This is largely over coaxial cable but with many short extensions by radio relay.

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Science and Electronics

COMPUTING DEVICES

In the field of large-scale computers there has been steady growth and expansion during the past year. The application of computing devices of all sizes to business procedures has begun to receive a large amount of attention and there are indications in the future that large-scale digital machines may replace a great deal of the clerical work now done by hand and by small machines.

In the field of large-scale analog devices one of the outstanding developments of the year was the completion of the computer for flight simulation which has been under development at Massachusetts Institute of Technology for a number of years. Built with the requirement that it solve problems as fast as they would be carried out in a physical situation, the machine may be used as a unit in itself or may be used in combination with parts of an aircraft to give almost complete flight simulation. The device is of large size substantially filling a room 25 feet by 50 feet.

In the large-scale digital field it may be noted that the

Figure 3. The BINAC under test

This medium-size general-purpose computer was delivered during the year to Northrop Aircraft Corporation by its manufacturers, the Eckert-Mauchly Computer Corporation

EDVAC, successor to the ENIAC, the first of the large-scale digital electronic computers, was delivered by the University of Pennsylvania to the Ordnance Department during the year. The EDVAC is a general-purpose computer. The Eckert-Mauchly Computer Corporation delivered a medium-size general-purpose computer known as the BINAC, Figure 3, to Northrop Aircraft Corporation. This marked the first such delivery of an electronic digital computer of appreciable size to a commercial organization by a manufacturer of computers. Virtually all previous digital computers have been built for government agencies with the exception of one for an educational institution and one built by International Business Machines for itself.

The coming year or so should see completion of a number of the big computers now under construction and an intensification of the race in the development of computers for new applications.

One topic which has been discussed recently has been the question of whether a-c calculating boards may be replaced by some of the new large-scale electronic computers. This is a problem which will receive increasing attention in the future.

ELECTRONIC POWER CONVERTERS

High-Voltage Rectifiers and Electronic Contactors. Ignitron tubes have been employed in several installations to supply power to the magnets of particle accelerators for atomic research. In these applications they function either as rectifiers to deliver direct current or as contactors to deliver current pulses to the magnet coil. In one arrangement the tubes serve as contactors which first discharge a capacitor into the magnet and then recharge the capacitor. In another they also provide a high-voltage d-c source for charging the capacitors. In a third arrangement the tubes operate alternately as rectifiers and inverters to transfer energy from a large flywheel motor-generator set to the magnet and conversely.

These applications make use of the high current capacity of the mercury pool tube. These tubes provide an economical and accurate means of obtaining a large amount of electric power for a short period at frequent intervals. A number of installations were made during 1948 and 1949 and others are in the process of construction. Figure 4 shows the rectifier assembly for one of these applications.

Electronic D-C Motor Drives.[1–3] Rectifier equipments with a wide range of voltage control have been developed for supplying power to adjustable speed drives. More than a score of applications have been made including drives for printing presses, fans, and metal working mills in ratings up to 400-kw output. These rectifier units consist of a set of ignitron tubes connected directly to a 3-phase 460-volt bus without a rectifier transformer and supply power to 550-volt d-c motors. A wide-range phase-shift network employing saturable reactors permits ready adjustment of rectifier output voltage by means of a small value of direct current. Rapid and accurate control of output to meet process needs is obtained through the use of an electronic regulator, amplidyne, or magnetic amplifier.

The electronic d-c motor drive features rapid, accurate, and flexible speed control with savings in space, weight, losses, and cost.

Mechanical Rectifier.[4] Also of note in the rectifier field is the mechanical rectifier employing synchronous contacts. This device was first developed and put into successful operation in Germany during World War II. Its manufacture has been undertaken in the United States and the first large installation was made in February 1949.

The mechanical rectifier offers advantages of high efficiency, small size, light weight, and low cost. It is particularly adopted to applications requiring high current at relatively low voltage.

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ELECTRONICS

Information Theory. The emergence of the concept of "information theory," as a means of extending and rationalizing the limiting boundaries of measurement and communication, by the use of statistical theory has been the most important and outstanding development during the year. A rapid spread of the interest in and application of the statistical theory of information has occurred in the various fields of electrical engineering using electronic circuits and instruments. Any current or signal in a circuit used for communication, control, or measurement purposes represents a choice out of a large number of possible currents or signals; a choice that cannot be predicted in advance. This current constitutes a "time series" with certain general statistical properties. Superposed on the chosen current there are fluctuations of various kinds, thermal noise in conductors, shot noise in vacuum tubes, fluctuations in the firing voltage of various gaseous relays, random errors in measurements in the coding of observed data, and so forth.

Thought of technologically, information theory deals with the properly critical selection of experimental data or other useful knowledge prior to transmission, the capability of circuits for propagation of the information, the optimum design of such circuits and the probability of errors, all taking into account the statistical properties of both signal and noise.

Thought of philosophically, information theory assists in evaluating and criticizing the effectiveness of human sense organs, thought processes, and information exchange processes. For example, an evaluation of Chinese relative to English as a written language is basically a problem in information theory.

Thus information theory may be thought of as a valuable link between certain aspects of technology and of philosophy. One of the best contributors on information, C. E. Shannon, has adapted his studies to the devising in considerable detail of a basic design for a machine able to play chess. This design study includes various aspects of information theory, including attention to the following questions:

1. What minimum information is necessary for the making of a reasonably correct decision as to what the next move is to be?
2. What types of criteria for wisdom of decision can be set up that a machine will recognize?

It appears likely that information theory will permit, in course of time, the establishment of genuinely adequate criteria for wise engineering decisions in all areas of technology involving instrumentation and intelligence transfer.

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Magnetic Amplifiers. The year 1949 may be recorded as the year during which magnetic amplifier technology made its appearance as an important means of power equipment control. The term magnetic amplifier as now employed represents a major expansion, as to fields of usefulness, circuit and equipment principles, and available magnetic properties, of certain long-known techniques of use of magnetic circuits, particularly those involving saturable-core reactors. The magnetic amplifier amplification closely parallels the field of use of electronic amplifiers and the principles and techniques of circuit analysis and assembly are closely related to similar practices for vacuum tube amplifiers.

A typical magnetic amplifier will employ a substantial a-c power source as more or less the equivalent of the d-c power source in an electron tube amplifier, the input signal frequency and useful power output frequency being lower by perhaps an order of magnitude than the power supply frequency. Amplification then results from nonlinear magnetic circuit properties associated with magnetic saturation.

Other rather different principles and techniques are also employed in devices that are called magnetic amplifiers, but all incorporate the following common features:

1. They provide means for rapid and flexible control of either modest or large blocks of power by means of nonrotating transformer-type equipment.
2. They employ only the simplest and most dependable types of rectifiers, or in some cases none at all.
3. A majority of recent applications employ nearly 100 per cent self-saturation or feedback, which greatly improves the gain and makes possible improved speeds.

In connection with the use of magnetic amplifiers having input and output frequencies in the low and intermediate audio range, from perhaps 30 to 3,000 cycles per second, it should be recalled that synchronously-driven rotating a-c power generators are commercially obtainable up to 10,000 cycles per second, and can be developed up to 25,000 cycles per second. Such machines may well serve as stable power sources for magnetic amplifiers.

One of the significant aspects of magnetic amplifier tech-

Figure 4. High-voltage pumped ignitron rectifier for power supply for particle accelerator

nology is that it offers promise of extension to indefinitely higher power levels. Probably it will also offer increasingly severe competition to electron tube amplifiers at modest power levels because of its features of permanence and reliability. The amplifying properties of the magnetic circuit elements do not alter with passage of time, and the elements themselves have unlimited life.

It appears certain that magnetic amplifier technology will continue to increase as to its importance in applications to power equipment control problems.

The Electron Wave Amplifier. The electron wave amplifier tube, publicized late in 1948 and early in 1949, introduces a distinctly new amplifier principle usable at microwave frequencies, that is, upwards of 1,000 megacycles. In principle, if two adjacent electron beams have slightly different velocities of electron movement, a microwave-frequency signal introduced on one of the beams will be amplified by a joint space-charge and field interaction between the two beams. This new development is as yet in an early research stage, and it is too early to discern its ultimate embodiment either as to form or field of usefulness.

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INSTRUMENTS AND MEASUREMENTS

There have been a considerable number of significant developments in practically all fields of instruments and measurements during the past year. Space permits only mentioning a few of them.

The development of the "butyl-molded" instrument transformer illustrated in Figure 5 affords opportunities to improve the insulating and thermal characteristics markedly over those of the impregnated transformers.

Figure 5. New butyl-molded instrument current transformer, designed for accurate indoor metering and relay services, which has been developed by the General Electric Company

Heretofore, in using electronic amplifiers, it has been necessary to accept the unstable zero of the direct-coupled d-c amplifier or the narrow frequency pass band (slow response) of the contact-modulated d-c amplifier. A new principle[1] brought forth during the past year permits the simultaneous elimination of both shortcomings. This desirable result is achieved by utilizing a contact-modulated d-c amplifier to apply zero correction continuously to a direct-coupled d-c amplifier. This principle also has been applied to amplifiers used for analog computing.

The art of telemetering for industrial applications has been making steady progress, notably toward the attainment of higher speeds of response. Electronic techniques are coming into more general use in terminal instruments as well as in transmission equipment. A new branch of telemetering, developed during and since the war for telemetering from mobile devices such as balloons, airplanes, and missiles, is now emerging from security regulations. This "mobile telemetering," while utilizing the old established basic principles, involves difficult problems posed by severe conditions of application. Developments in this field will doubtless benefit industrial telemetering, and will encourage more extensive use of the radio link if suitable frequency bands are available.

The growth of the importance of industrial spectroscopy in the manufacturing and processing industries has been gradual but steady, through the war and postwar years. It is probably difficult to justify singling out 1949 as a year unique in the growth of this art, but it probably will be equally difficult to single out any other year. However, 1949 can be marked as a year in which there has been a substantial growth in realization on the part of electrical engineers that industrial spectroscopy involves primarily the technology of electric devices, rather than being in essence a metallurgical or chemical analysis art. Industrial spectroscopy includes presently activities in the following frequency ranges of the electromagnetic spectrum:

1. Visible and near-visible spectroscopy, as used with the technology of electric sparks, circuit transients, and cathode-ray oscilloscopes, to accomplish complete quantitative industrial alloy analyses in a matter of minutes. Also visible spectroscopy as applied to color analysis and industrial quality control.

2. Infrared spectroscopy, as used especially in the petroleum and pharmaceutical industries, for the separate identification of closely related hydrocarbons during various stages of research, process development, and production.

3. Microwave spectroscopy,[2–6] in which spectrum lines in the microwave range have been developed as frequency standards and for use in atomic clocks to give a new standard of time, the stabilization of microwave oscillators by these methods to obtain new means of frequency control, the development of microwave frequency dividers for use with stable oscillators and potentially capable of use for identifying certain molecular constituents of gases.

The common elements in all of these regions of the spectrum are the manner of presentation of end information, as spectral lines or absorption bands quantitatively identified on a frequency chart, and present or prospective industrial utility for rapid and precise determination of constituents

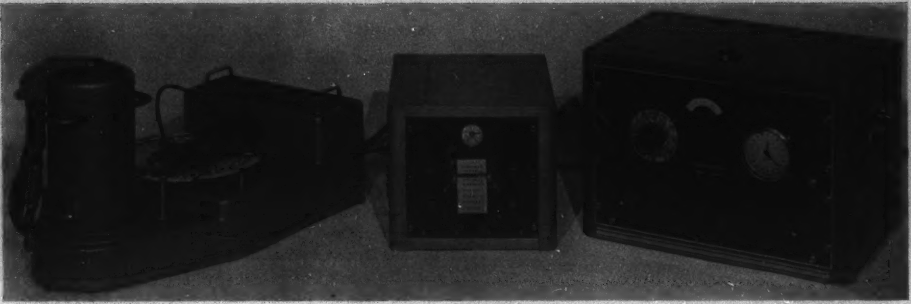

Figure 6. Tracergraph printing interval timer and the automatic sample changer

of alloys, fluids, gases, and so forth. Like many other electronic arts, industrial spectroscopy represents an economically important instrumentation service to industry.

Resonant cavity methods of measuring dielectric constants[7] in the radio and microwave ranges have led to several interesting measurement equipments, such as a recording refractometer applicable to radio propagation measurements and a perturbation method using small cylinders of the sample to make rapid and easy-to-calculate dielectric determinations.

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NUCLEONICS

Radiation Measurements. While it is difficult to evaluate the developments in a field as new and variable as this one, it seems that the following three facts are most apt to come up in any discussion of the subject.

1. The scintillation counter, which has been the subject of intensive development during the past few months, has reached the stage of being a practical device for measuring radiation intensity of gamma or X rays and for laboratory counting of alpha and beta particles.

2. The photographic emulsion technique for showing particle tracks which has been in use for approximately three years was developed during 1949 to the point where high-energy electrons can be detected. With the newer emulsions this technique is now equal in sensitivity to the cloud chamber.

3. Perhaps the most significant advance from an engineering viewpoint has been the increase in the number and type of radiation instruments which have been made available on the open market. Included have been a variety of improved survey instruments, pocket dosimeters of the self-reading type, and a variety of radiation counters including many special devices heretofore constructed in laboratories. Figure 6 shows the tracergraph printing interval timer and automatic sample changer as developed by Tracerlab, Inc.

High-Energy Particle Accelerators. In this field considerable progress was made during the year. Successful operation of the University of California Radiation Laboratory synchrotron at Berkeley at energy levels in excess of 300 million electron volts was achieved in January and production of mesons with these radiations was found almost immediately. An announcement was made during the year of the start of construction on proton synchrotrons at Brookhaven National Laboratory and at the University of California Radiation Laboratory. These units have been named cosmotron and bevatron, respectively, and are expected to produce energies in the several billion electron volt range. Several accelerators purchased by various laboratories were received during the year including a 100-million electron volt betatron at the University of Chicago, a 50-million electron volt betatron at the Bureau of Standards, a 70-million electron volt synchrotron at Queens University in Ontario, Canada, and a 3.5-million electron volt electrostatic accelerator at Brookhaven National Laboratory. Finally, it was announced that X rays from a 25-million electron volt betatron had been used for the first time in cancer therapy on human patients at the University of Illinois Medical School.

Very little of the foregoing information has been described in the engineering literature although a number of papers covering the radiation instrument category were presented at the Second Annual Joint Institute of Radio Engineers/AIEE Conference on Electronic Instrumentation in

Nucleonics and Medicine, New York, N. Y., October 31, November 1–2, 1949 (see pages 68–71).

General Applications

COMMERCIAL APPLICATIONS

Heat Pumps. During 1949 a number of residential and commercial heat pump installations were field assembled from standard devices. Carrying forward a program for securing accurate data, one manufacturer in co-operation with a group of utility companies has engaged in a field test program of packaged units in residences, offices, a store, and a clinic. These units are completely automatic and use air as a primary heat source, although water or ground coils are used in some instances as supplementary sources. Each installation is completely instrumented, with automatic cameras recording all readings periodically.

Automatic Clothes Washer. Few domestic appliances have seen so rapid a growth in recent years as the automatic clothes washer, which washes, rinses, and partially dries the clothes in an automatically timed cycle of adjustable length, thus saving the housewife from a large part of the wash-day burden. Characteristic of a new engineering development, there have appeared a variety of different mechanisms, methods of washing, methods of transferring from wash or rinse to extracting, and various methods of extracting. Washing has been done principally by two methods, a reciprocating agitator, and a continuously rotating tumbler. Extracting has been principally by centrifugal action in a spin-basket, or by squeezing under hydraulic pressure through a flexible diaphragm. Centrifugal systems are usually automatically balanced, sometimes by the wash water itself.

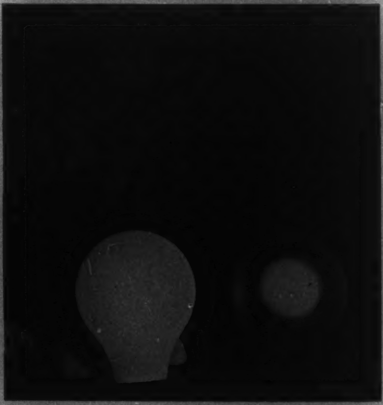


Figure 7. A new method of coating the interior surface of lamp bulbs with a pure silica coating of extremely fine texture, announced by the General Electric Company, diffuses the light uniformly over the bulb with no loss of light

The lamp at the left has been treated with the new process; the lamp at the right has the former inside frosting

Trends in Household Refrigerators. Few radical changes in household refrigerators were recorded in 1949. Smaller compressors and other space saving changes introduced in 1947 and 1948 were continued. The trend in evaporators seems to be more to the horizontal type, and there has been a noticeable increase in the 2-temperature or combination refrigerator, with a frozen foods section maintained at near zero temperatures, and a fresh food section maintained with temperature and humidity zones appropriate to fresh foods. In home freezers a trend has developed towards larger capacities, the 9 to 13 cubic foot class gaining at the expense of smaller sizes.

LAND TRANSPORTATION

Two noteworthy developments in the application of electricity to land transportation during 1949 are the gas turbine electric locomotive and the rectifier equipment for operating railway cars with standard d-c traction motors from single-phase a-c contact systems.

The gas turbine has been developed experimentally during the past decade, but not until this past year has the design been worked out in complete detail for the satisfactory operation of a locomotive, which has been used in commercial service on tests during the past six or eight months. The electric drive, while similar to that which has been so successfully applied to diesel electric locomotives, has been further modified to fit the higher speed characteristics of the gas turbine. The control and auxiliary equipment developed specially for this locomotive are also, for the most part, electric. (Photo in pictorial section.)

The mercury arc rectifier was used experimentally early in the development of the a-c electrified railroad, a car of this type having been used on the pioneer a-c electrified steam railroad in 1914. Difficulties in maintaining vacuum, and inductive disturbances due to higher harmonics on neighboring communication lines, were disadvantages which indicated the necessities of further study in design for corrective measures. The development of the "ignitron," which has been so successfully applied to a-c rectification in stationary substations during the past decade, and the further refinements in design in this apparatus brought about during the war, has renewed the study of this equipment for application to a railway car for operation on single-phase a-c electrified railways, and such a car has actually been in experimental service on a large electrified railway in the United States during the past six months.

PRODUCTION AND APPLICATION OF LIGHT

Progress in the production and application of light has been steady during 1949. A very few of the significant developments in lamps and their applications are given as typical of the general advance in this division of electrical engineering.

The familiar incandescent filament lamp has been improved by an inside coating of pure silica of extremely fine texture which diffuses the light uniformly and efficiently over the bulb (Figure 7). The fluorescent lamp, while unchanged in outward appearance, has new phosphors which are much better in color quality than those formerly used and combine good color rendition with efficiency. The beryllium phosphor, which had some toxic properties when the lamps were broken, is used no longer. Mercury street lamps have been equipped with electromagnets positioned over the arc which keep the arc stream centered in the tube and thus increases lamp life during horizontal operation. A new flashtube was developed which is capable of making thousands of flashes at a speed of 1/5,000 of a second and makes possible light and economical flashtube equipment for the photographer.

In the light application field, a new system has been announced for guiding airplane pilots to safe landings during poor visibility conditions. The "slope line" approach lighting system was developed by the Civil Aeronautics Administration and was approved as standard by an Air Force–Navy–Civil committee. It consists of a number of sloping lighting units installed on each side of the approachway to a landing strip (Figure 8), the two rows of lights forming a funnel which converges on the runway. The pilot can correct his approach according to the pattern of the lines of light. This pattern will appear as two long continuous lines leading to the runway if the approach is correct or as individual short lines which will indicate the direction and magnitude of the error if the approach is wrong.

Of interest also is an air-pressure explosion-proof lighting unit for use in highly hazardous locations. (Photo in pictorial section.) The fixture is designed for operation with a positive air pressure in the lamp compartment, thus preventing entrance of surrounding hazardous atmospheres. Loss of this pressure operates a switch to extinguish the lamp.

Fluorescent lighting has been applied to motor coaches by means of a special variable frequency–constant voltage circuit which operates slimline lamps from the alternator of an alternator-rectifier power system. (Photo in pictorial section.) A unique feature is the method of starting the fluorescent lamps by means of the reactor and capacitor of the circuit. As the frequency is increased the voltage across the lamp increases as the reactance–capacitance combination approaches resonance. Thus it is only necessary to increase the engine speed until the lamps start. The lamps will then remain lighted when the engine speed is decreased.

Figure 8. A closeup of the lighting fixtures of the "slope line" approach system

Each fixture is 14 feet long and is equipped with ten sealed-beam-type lamps

Power

POWER GENERATION

Expansion of central station capacity in the United States has reached an all-time peak with scheduled additions of 6,929,201 kw during 1949. Scheduled additions (at this time) for each of the years 1950 and 1951 are over 6,000,000 kw. Over 4,000,000 kw are already scheduled for 1952. Total installed capacity as of December 31, 1949, will be about 63,000,000 kw.

New records are being established in point of size and type. A 1,300,000-pound-per-hour steam generator is planned to supply steam at 1,050 degrees Fahrenheit and 1,500 pounds per square inch gauge. A 62,000-horsepower vertical shaft Pelton wheel went into service in Canada running with a head of 1,200 feet. About 26 units will be installed using the reheat-regenerative cycle with initial and reheat temperatures in the 1,000 to 1,050 Fahrenheit range.

The first gas turbine went into service on a commercial basis in Oklahoma City. This 3,500-kw unit works in conjunction with a steam station having limited boiler capacity. It produces a net gain in total station capacity of 7,000 kw at a slight gain in over-all efficiency. A total of five gas turbines for service on central station systems are on order, or under construction.

The application of house turbines as auxiliary supply sources in central stations have been used in a number of instances. There has been increased use of separately driven exciters and systems using amplidyne, rototrol, and regulex exciters, as well as all-electronic exciters and voltage regulators.

Increasing use is being made of various calculating devices and analog computers to obtain practical guides and conclusions in the design and applications of excitation systems.

Considerable work has been done in checking speed governor characteristics of steam turbines under running conditions. Many older mechanisms have been replaced with ones of modern design. The improved performance has markedly reduced the system frequency fringe and allowed better use of automatic supplementary frequency controls, especially on tie lines.

RELAYS

A new-type overcurrent relay with extremely inverse characteristic has been developed which allows lower fault protection settings while not tripping on the inrush current

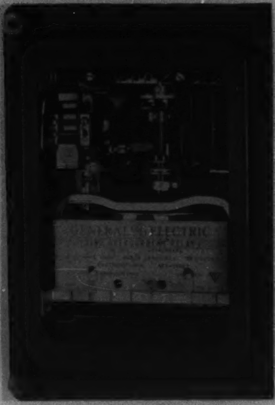


Figure 9 (above). General Electric time overcurrent relay

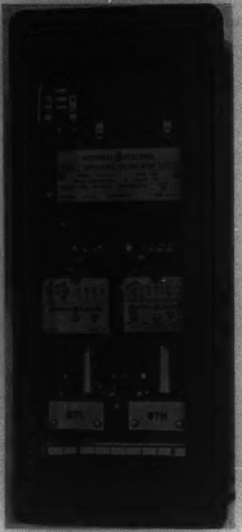


Figure 10 (right). General Electric differential voltage relay

of a feeder after an extended outage. This relay features the novel use of a wattmetric-type operating magnet with the coils connected in series and can be more readily coordinated with fuses than the present-time overcurrent relays now in use.

An overcurrent relay which provides adequate fault protection for most distribution feeders and picks up loads after outages of sufficient duration have brought the loads of automatic devices onto the lines has been developed and was announced recently by the Switchgear Division of General Electric Company.

Usually when a feeder is re-energized after an extended outage the accumulation of loads causes an inrush current to flow. This, in many instances, exceeds the minimum value of short-circuit current which good protection dictates the feeder overcurrent relays should be set to clear.

The indicated solution was an overcurrent relay with a much more inverse characteristic than that of the so-called "very inverse" relays. Such a relay having an extremely inverse time characteristic curve with a shape approximating those of power fuses and distribution cutouts has now been put in production.

The new relay has the usual features of other overcurrent relays such as time dial, tapped coil, single contact with target-seal-in device, and provision for instantaneous attachment. It is shown in Figure 9.

A new relay for bus differential protection, operating on a differential-voltage principle, has been developed for high-speed protection of station busses and switchgear on moderate to severe internal faults. The relay has a high impedance when compared with conventional differential-overcurrent relays, and can be adjusted for greater sensitivity to internal faults with more margin against false operation on heavy fully offset external faults. It can be applied on a wide range of bushing current transformers with performance subject to simple calculation.

This relay is easier to apply and provides faster and more sensitive protection than the conventional multiple-restraint or differential-overcurrent methods. A simple relay without restraining coils is used and differs from the differential overcurrent relay in having a relatively high impedance, of the order of hundreds rather than tenths of ohms. As a result, minor differences between current transformers do not result in appreciable current flowing through the relay, but adjust themselves through redistribution of the induced voltages that drive current around the secondary loop. Under internal-fault conditions the voltage across the paralleled current transformers and relay rises to the a-c saturation value of the order of several hundred volts, but under external fault conditions the voltage across the relay and current transformers does not rise to more than a fraction of this value. In other words, the relay operates on a differential-voltage principle. Figure 10 shows this relay.

Industry

CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS

Production in the chemical industry at the present time is approximately four times the 1935 to 1939 average. This tremendous increase has necessitated changes in production methods in this industry. More and more plants and processes are switching over from batch to continuous-type production, and chemical plants are being continually enlarged. New plants being built are of an ever-increasing size. These factors are of considerable interest to the electrical industry for several reasons. Large-scale continuous operation requires more automatic control, more efficient material handling equipment, and more instrumentation. All of these developments provide large markets for, and require the attention of, the electrical industry.

As these plants become larger, the atmospheric problems become more severe. Consequently, an ever-increasing effort is being put forth by the chemical and electrical industries first to clean up these hazardous and corrosive atmospheres, and, second, to provide equipment suitable for operation in these atmospheres where it is not possible to remove the corrosion or explosion hazards. The electrical industry must continue to give special attention to the further development of air circuit breakers, switchgear, and control items, as well as special design of motors for application in these locations.

The expansion of chemical plants plus the increased competition in the chemical industry are influencing the use of electric power generation equipment. As competition in the chemical industry increases, the profit margin on their products is reduced to the point where it becomes economical to put their investment capital into electric power generation plants rather than into additional production facilities. Also, the requirement for large quantities of process steam has greatly influenced the trend to more and more power generation by chemical companies.

Paradoxically, the electrochemical industry has been going to both higher and lower voltage requirements for conversion equipment. A large number of plants are expanding and are going to longer cell lines and consequently higher voltage. Conversely, due to the basing point system and an increasing number of applications where relatively small quantities of chlorine, caustic, and the like, are required, smaller, lower production, and lower voltages are being considered. This has put a demand on the electrical industry for conversion equipment with increased efficiency over a wider voltage range.

The use of electricity in the electrothermal industry is also increasing. The increasing use of chemical fertilizers to correct soil deficiencies has taken a decided upward trend in the past decade. The availability of low cost hydroelectric power near large phosphate rock deposits has made the electric arc furnace process economical in the manufacture of phosphatic fertilizers. Calcium carbide, at the present time made only by the electric furnace process, is widely used in the plastics industry which is rapidly expanding. These developments necessitate special equipment.

Another interesting development has been the recent use of electricity to melt glass, which is quite new in this country and in which widespread interest has developed. As this development expands commercially, the electrical industry will be called upon to furnish special regulators and variable-voltage a-c power supplies for this industry. Considerable development work is still required by the glass and electrical industries co-operating in this field.

The electroplating industry has been interested for a number of years in the use of PR or reverse current plating. Recently, copper plating by this method has become practical; however, other phases of this work are still in the experimental or pilot plant stage and further developments of the process and special characteristic a-c–d-c converters are required before commercial production can be attained.

ELECTRIC HEATING

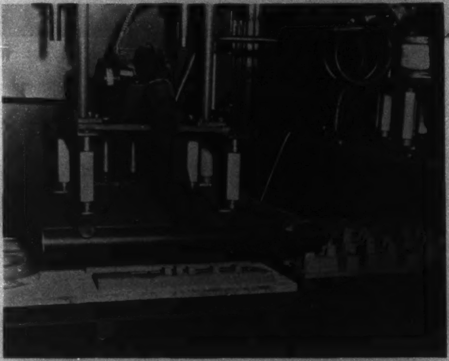
Developments in electric heating in 1949 have been refinements, and extension of present techniques into new fields.

With suitable electrode materials available and with electronic current control to regulate the heating, continuous glass melting by passing current through the molten glass is being considered by a number of companies.

Molybdenum resistors and protective atmosphere are used in small high-temperature furnaces to operate over 3,000 degrees Fahrenheit for sintering, melting, and ceramic firing at temperatures normally not obtainable by other heating elements.

A recent development has been the use of rod-type heating elements with aluminum reflectors to provide radiant heat for such applications as moisture evaporation, food processing, and so forth, where glass bulbs may not be desirable. These metal-sheathed heaters are rated from 30 to 50 watts per square inch, give upwards of 6,000 hours service life with heat transfer to the working surface of as much as 4,500 Btu per square foot.

Figure 11. Battery of units with pumps and controls for fluid heat transfer



Induction Heating Corporation photo

Figure 12. Dielectric heating of sand cores in a foundry

In the high-temperature process industry (600 degrees Fahrenheit) fluid heat transfer fluids using high-velocity forced circulation is being more widely used for heating jacketed vessels, platens rolls, and so forth. Figure 11 shows a battery of these units with pumps and controls installed recently at Wilson Organic Chemicals Company, Sayreville, N. J.

A growing application of dielectric heating is found in modern foundries. Sand cores used for complex castings are mixed with a small amount of heat-setting binder and baked in a few minutes, compared to as many hours with convection ovens. The same equipment handles a wide variety of sizes, and shapes of cores. (See Figure 12.)

(*Continued on page 24*)

◀ A standard table model black-and-white television receiver which can also be used for reception of Columbia Broadcasting System color signals by means of the color converter. This set, which also has a scanning adapter, can receive black-and-white signals, and when the converter is slid into place between the face of the picture tube and the viewer, it will reproduce signals in full color.

1949 ENGINEERIN

A photographic record of some of the importa

▲ The camera, which is used with the CBS system of color television, employs a standard black-and-white image orthicon with a single-image and a 12-segment color disk revolving at 720 revolutions per minute.

◀ The motion picture film scanner developed by the Columbia Broadcasting Company that is used in conjunction with the CBS system of color television.

▶ The control units of the all-electric color television system developed by the Radio Corporation of America which have been installed at the National Broadcasting Company station WNBW, Washington, D. C. It was from this station that signals were broadcast on channel 4 during the demonstrations for the Federal Communications Commission.

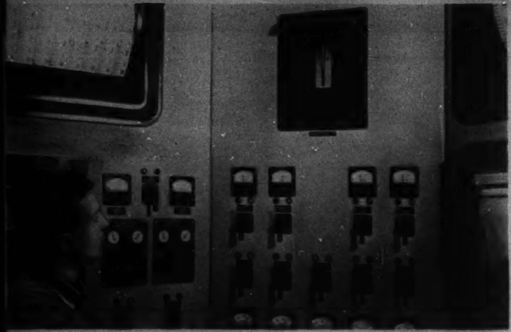
DEVELOPMENTS

ectrical engineering achievements of the year

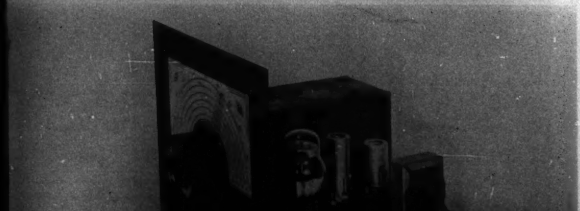
▲ Color television camera of RCA with cover removed shows the two dichroic mirrors in front which allow the green rays from the object to pass through to the lens of the center image orthicon tube, while reflecting red rays by a silver mirror to the right-hand tube and the blue rays by another mirror to the third tube on the left.

▲ The 16-millimeter color motion picture projector which is one of the units of the RCA color television system, at Station WNBW. The electronic sampler is on the left.

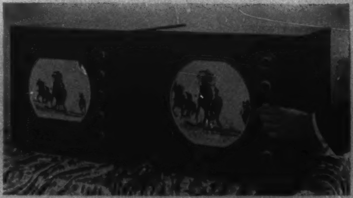
◀ Sixty images per second of a distant operating gauge or instrument are transmitted to a central control point by the Diamond "Utiliscope" system, furnishing continuous inspection facilities to an operator. In the upper illustration the camera of the system is shown permanently focussed on a boiler drum water level gauge in the Tidd Station of the Ohio Power Company. From this remote point the image of the gauge is transmitted by wire to the screen on the control-room wall, shown below. The "Utiliscope" is a product of the Capehart-Farnsworth Corporation, domestic television and radio manufacturing subsidiary of the International Telephone and Telegraph Corporation, and the Diamond Power Specialty Corporation.



▶ An increase in picture size of television receivers has been made possible by the use of a metal-cone picture tube 16 inches in diameter. The method of sealing the glass face-plate and glass neck to the chrome steel of the cone was developed by the Radio Corporation of America. The illustration at the right shows the 16-inch tubes emerging from the oven where the fluorescent screen face and the inside conductive coating are baked at temperatures ranging from 385 to 400 degrees centigrade.



▲ In order to adapt experimental ultrahigh-frequency television broadcasts to resent commercial channels, a converter and separate special circuits have been eveloped. Below the chassis of the converter are shown the cylinder oscillator ith an acorn tube, a modified "semibutterfly"-type oscillator with a half-cylinder otor, and a special crystal mixer that functions from 475 to 890 megacycles. These were developed by the Stanford Research Institute.

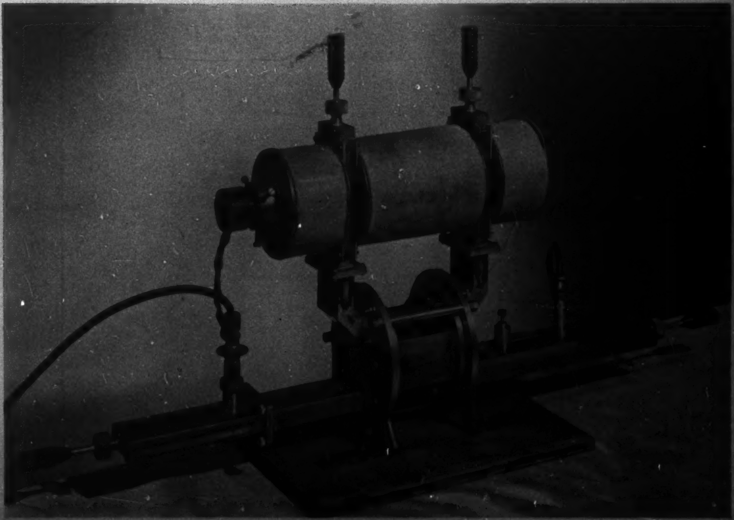


▲ A development in the television receiver field is the "electronic magnifier" which enlarges a 12-inch picture horizontally and vertically to the equivalent of an 18-inch image. When the magnifier switch of this receiver, developed by Westinghouse Electric Corporation, is thrown to increase the picture size, a movable eyelid mask recedes to accommodate the enlarged close-up image; simultaneously, the voltage of the electronic circuits is increased so that the sweep circuits have the same power required to operate an 18-inch tube.

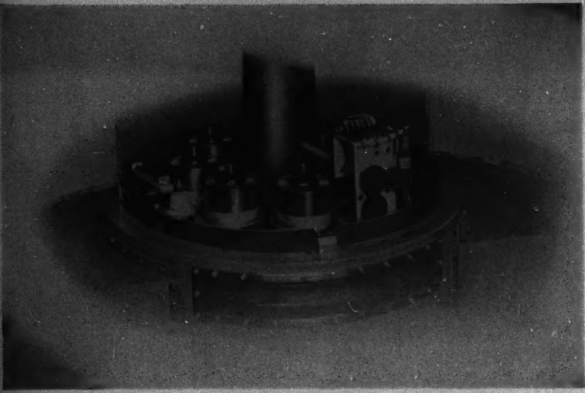
▶ Mechanization of telegraph facilities by means of facsimile apparatus progressed last year with the installation in nine cities of central office equipment and patrons' transceivers by the Western Union Telegraph Company. Two operating positions, each with six recorders and four transmitters, are illustrated above and a patron's desk transceiver is shown below. When typing a message for transmission, a copying paper is used which provides insulated characters on an electrically conductive paper, which is wrapped around the revolving drum and scanned by a stylus in the traveling arm. An electrically sensitive recording paper is used for reception of messages, which are reproduced by the same stylus that causes the paper to change color when current passes through it.

5600
Western Union
Telefax

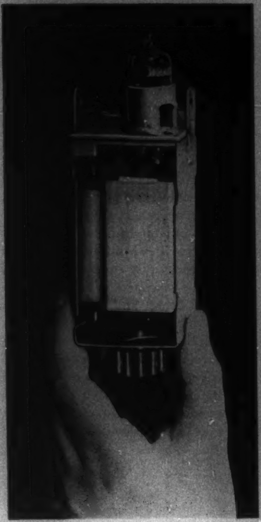
◀ A feature of a new telephone instrument is an equalizer which automatically adjusts the sound level to compensate in part for the distance between the telephone and the central office. The dial on the new set, developed at Bell Telephone Laboratories, has the numbers and letters outside the finger wheel and it is at a lower angle for better visibility. A volume control is on the ringer, which is lower pitched than formerly and more resonant. The new model is smaller, affording a better fit to the head, and the weight of the handset has been reduced 25 per cent.



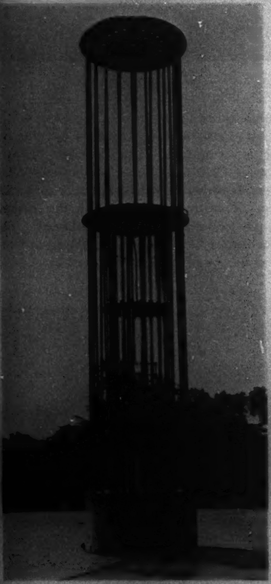
▶ One of the outstanding developments of the past year was the traveling-wave amplifier, which is capable of producing 140 milliwatts of power for a pass band of 1,400 megacycles in the 5,000-megacycle region. The gain of 25 decibels is adequate for use of this equipment, developed by the International Telephone and Telegraph Corporation, in unattended repeater stations for long-distance microwave communication systems.



▲ A novel arrangement of components is incorporated in a new high-frequency, high-power amplifier, which can be utilized either as a complete 50-kw frequency-modulated transmitter, or an amplifier to convert existing 10-kw frequency-modulated transmitters to 50-kw operation; the equipment couples directly from a 10-kw driver to the antenna system with only one stage. Eight air-cooled triode vacuum tubes are used in a concentric, symmetrical design and only three tuning adjustments are required. This is a product of the Westinghouse Electric Corporation.



▲ The miniature vacuum tube made possible a new repeater not much larger than a pack of cigarettes. It occupies one-sixth the space of earlier units, costs less, and in the event of failure, it can be replaced like a blown fuse in a matter of seconds. This development of the Bell Telephone Laboratories comprises two amplifiers, one for each direction of transmission. Besides the vacuum tube, the components of each amplifier consist of input and output transformers, gain potentiometer, resistors, capacitors, and jacks.



▲ A new type of antenna system for radiating accurate azimuth information to aircraft, operates as a source of pure horizontal polarization and exhibits a high degree of azimuth calibration in the 112- to 118-megacycle range. This antenna has been developed for the Air Material Command's Watson Laboratories by the Federal Telecommunication Laboratories, the research unit of the International Telephone and Telegraph Corporation.

CONTROL UNIT
MAIN UNIT

▲ The air-borne course-line computer directs aircraft to any destination within radio range of special radio ground facilities which determine the origin of a polar co-ordinate system. Destination co-ordinates and the course to be flown are fed as data into the main unit, the electronic computer, which also receives continuous data of the aircraft's location with respect to the origin. From these data the computer determines deviation from the desired course and distance to destination. Equipment developed by Hazeltine Electronics Corporation.

◀ **Dubbed the "close-spaced triode," this new electron tube developed by the Bell Telephone Laboratories has a grid-cathode spacing one-fifth the diameter of a human hair. This minute gap permits use of the triode at extremely high frequencies. The tube will be used in repeater and terminal equipment in the New York–Chicago microwave radio relay system.**

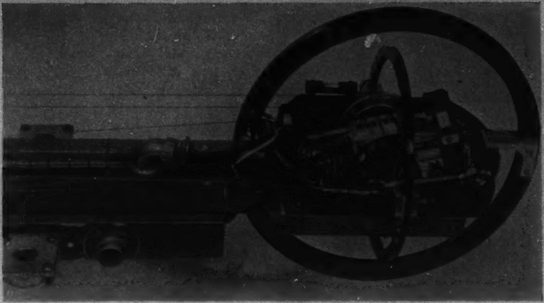
▲ **Shown is an early model of the Graphecon, RCA electron tube which electrically stores for one minute radar signals lasting one millionth of a second. Employed between signal-receiving and kinescope stages, the tube permits boosting of signal strength so that kinescope trace can be seen in a well-lighted room.**

▲ **First precise determination of the absolute value of the proton's magneti moment was made at the National Bureau of Standards, using a nuclea resonance technique. Proton sample, ordinary water enclosed in a glas ampule surrounded by a small radio-frequency coil, was inserted betwee pole pieces of a magnet. At certain values of magnetic field and radi frequency, there is a sudden shift in amount of energy absorbed by th protons, which alters the Q of the radio-frequency coil. Knowing thes two critical values of field and frequency, one can compute the magneti moment of the proton. The long rectangular glass plate is a device fo measuring magnetic field of pole pieces. Value of magnetic moment o proton obtained was $(1.4100 \pm 0.0003) \times 10^{-23}$ gauss centimeter cubed.**

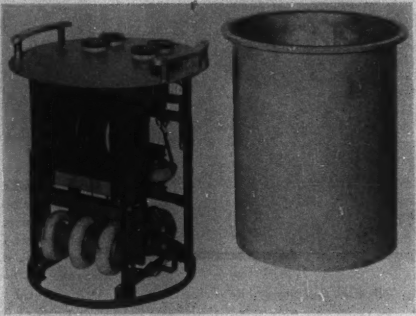
▶ **This electrostatic accelerator, shown in the General Electric Company's General Engineering and Consulting Laboratory, is under construction for The Brookhaven National Laboratory, at Upton, N. Y. In operation, electrostatic charges are carried from one end of the machine to an aluminum sphere at the other end by two moving belts. Not yet installed, these belts will travel between the two long horizontal tubes. The voltage accumulated on the sphere will serve to accelerate a steady stream of protons through the accelerator tube to a target where subatomic reactions are studied.**

RADIOGRAPH
LAMINAGRAPH

▲ The spiral laminagraph, an instrument developed by the Naval Ordnance Laboratory, permits X-ray exposures to be made of selected planes within an object. This feature enables the radiologist to determine with great accuracy the internal structure of small mechanisms. Such studies are not possible with conventional X-ray apparatus, since the picture obtained is an over-all view with effectively no depth selectivity. Ordinary radiograph and laminagraph pictures are compared in the inserts at the left.



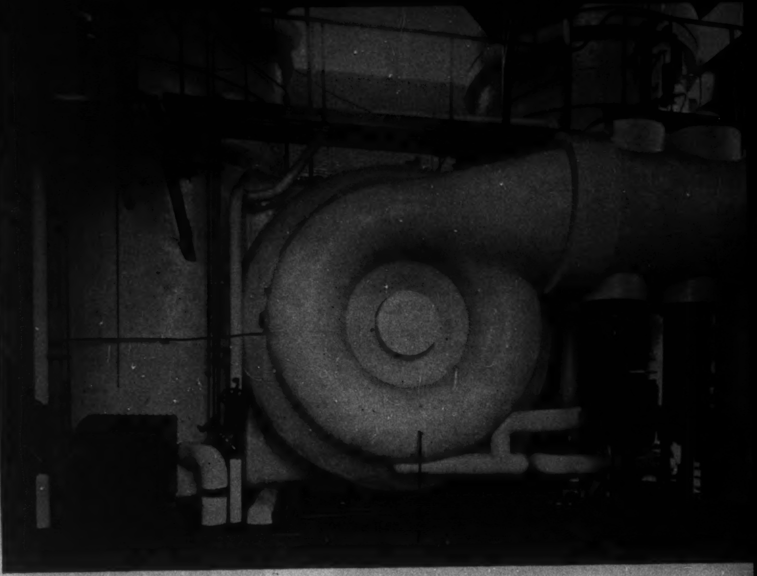
▲ This is the heart of the air-borne magnetometer, an instrument developed by the Naval Ordnance Laboratory for measuring the earth's magnetic field vector. The apparatus is an improvement on the total-field air-borne detector which was developed during the past war by NOL and the Bell Telephone Laboratories for submarine detection. More complete geophysical reconnaissance surveys will be possible with this device. Geomagnetic data for keeping navigational charts up to date also will be gathered by the magnetometer.



◀ This X-ray transformer and full-wave rectifier, rated at 100 peak kilovolts at 100 milliamperes, was developed for military field medical installations to specifications of the Surgeon General and the National Bureau of Standards. Oil leaks are avoided by using sulfur hexafluoride gas as the insulating medium.

◀ A sound measurements reference laboratory, valuable in developing telephone apparatus, was built at Murray Hill, N. J., by Bell Telephone Laboratories engineers. Walls, floor, and ceiling of the test room are treated with sound-absorbing material. Sound instruments to be measured are suspended from supports in the ceiling. The measurements system is contained in the seven bays at the right. There are facilities for recording: frequency-response characteristics from 20 to 100,000 cycles per second with continuous or pulsed signals; noise with variable - band - width filter; harmonic and modulation products for fixed frequency input signals; and continuous fixed order harmonics.

▶ On January 2, 1949, firing was started under the new mercury boiler installation in the South Meadow Station of the Hartford Electric Light Company. This unit of 33,000-kw net capacity is the first of several postwar mercury power plants to be placed in service. Designed and supplied by The General Electric Company, the equipment uses mercury vapor at 113 pounds per square inch gauge and 945 degrees Fahrenheit to drive a mercury turbine at 720 rpm. The unit generates 15,000 kw and also supplies about 200,000 pounds of steam per hour at 400 pounds per square inch gauge at 700 degrees Fahrenheit to drive existing steam turbines.



▶ A large a-c network analyzer has been installed in the offices of the Chief Engineer at the Denver Federal Center to make possible the study in miniature of the planning and design problems of power systems in the western states. The analyzer has been built so that it may be expanded as future computation needs develop. Features of this General Electric product are light-beam-type meters and a switch which simultaneously changes the current shunts and scales of the light-beam ammeter and wattmeter-varmeter instruments so only one scale need be checked at a time. Highly versatile, any circuit may be metered by the use of numbered pushbuttons.

▶ The first central station installation of the gas turbine in the United States was put into use by the Oklahoma Gas and Electric Company in July. Built by The General Electric Company, the 3,500-kw simple-cycle plant weighs only 25,000 pounds including compressor and gas turbine unit. Its small weight and size (9 by 50 feet) make it desirable for adding capacity to existing stations.

One of the heaviest shipments in Allis Chalmers' history is own being loaded on a special flatcar at the West Allis Works. his 1,800-rpm generator, rated 125,882 kva, 82 per cent power ctor, 18,000 volts, will be driven by a 107,000-kw steam turbine. he 375,510-pound, completely-wound stator, 29½ feet long, 13½ feet in diameter, was shipped sealed.

Opened for public inspection for the first time in June was e new Sewaren Generating Station of the Public Service lectric and Gas Company of New Jersey. Shown is the Number turbine generator built by Westinghouse, the first of four to be stalled in the station. The total capacity of the station will e 425,000 kw. The first three units, which are in service now, re each rated at 100,000 kw, 3,600 rpm, with steam pressure of ,500 pounds per square inch and steam temperature of 1,050 egrees Fahrenheit. The fourth unit, to be installed by 1951, will be rated at 125,000 kw.

► These three General Electric oil-filled transformers, rated 20,000 va air-cooled or 25,000 kva forced-air-cooled, 138,000/13,200 olts, are shown at Receiving Station "F," City of Los Angeles, De- artment of Water and Power. They are a part of the over-all xpansion program which the department has been carrying out ince the end of the war, and form one of a series of six receiving tations grouped in a circle around Los Angeles. The six stations are nterconnected by a ring bus. The receiving stations differ from e stations they supply in that they receive power from the Harbor team Plant at 138,000 volts, from the Seal Beach Steam Plant at 38,000 volts, from Hoover Dam at 287,000 volts, and from the San Francisquito Power Plant at 11,000 volts.

▲ This 3-phase 145,000-kva transformer, the most powerful ever built, is shown being lowered into the test pit at the transformer plant of the Westinghouse Electric Corporation, Sharon, Pa., for the final tests before shipping. It was recently shipped to the Detroit Edison Company for installation at the Trenton Channel Station where it will convert generation voltage of 15,000 volts to 135,000 volts for transmission. Modern engineering developments made possible a smaller and lighter weight unit than was possible even with much less powerful transformers in the past.

▲ The most powerful lightning bolts ever created by man leap between the two 5,100-kv impulse generators (maximum peak voltage 7,500 kv) in the high bay of the new General Electric High Voltage Engineering Laboratory at Pittsfield, Mass. The generators, each 44 feet high, can be connected in parallel to obtain a 60,000-ampere discharge or connected in series to develop 10,200,000 volts (maximum peak voltage 15,000,000 volts) and a 50-foot arc.

▲ A front view of the new High Voltage Engineering Laboratory shows only the low-bay building containing the offices, photographic darkrooms, power room, and smaller high-voltage test laboratories. The tall building, visible in the rear, is High Voltage Hall, which houses the two impulse generators shown above.

▲ One basic objective of research in the new GE High Voltage Laboratory is to determine the effects of lightning on power transmission lines. Outdoors, a 7,500,000-volt bolt of lightning can be shot at a test line. The giant generator is moved from inside on a small flat car through a door 50 feet high.

▲ Three 350-kv transformers in the GE High Voltage Laboratory being cascaded to give 1,050 kv rms to ground.

▶ Shown in the controlled-temperature room are a 300-kv testing transformer (left), 750-kv impulse generator (center), and 50-centimeter sphere gap. The room was constructed of especially insulated aluminum walls and will be used to conduct high-voltage tests in temperature conditions varying from 0 to 100 degrees Fahrenheit and varying degrees of humidity. Huge refrigerator-type doors provide access to the room.

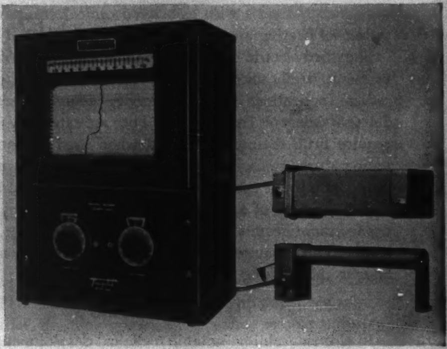
◀ Now in freight service on the tracks of the Union Pacific Railroad is the nation's first gas turbine-electric locomotive. The 4,500-horsepower unit built by the American Locomotive Company and the General Electric Company can travel 12 hours before refueling is necessary; it develops 53 horsepower per foot of length and is geared for 79 miles per hour. Prime objectives in building the gas turbine-electric locomotive were to have a prime mover that burns low grade fuels, especially coal, economically, gives higher power output per pound and per cubic foot, and has reliability and low maintenance cost.

◀ An internal view of a Chicago motor coach, believed to be one of the most efficiently lighted busses in the country. Its fluorescent lamps, using a new circuit developed by General Electric, are operated at frequencies up to eight times higher than in normal installations. The new principle of operating fluorescent lighting systems at high frequencies is expected to find other applications in commerce and industry.

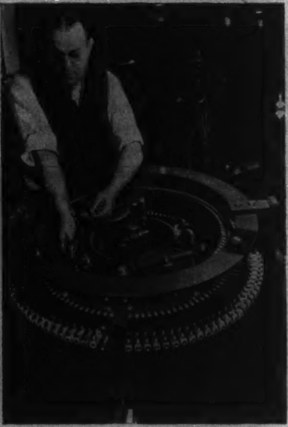
▲ A lighting fixture for use in dangerous atmospheres has been developed by Safe Lighting, Inc. The fixture is designed to be used with about ten pounds of air pressure in the lamp compartment. The air pressure holds a circuit switch closed by means of a bellows. Loss of pressure due to leakage releases pressure on the bellows operating the switch, and the circuit is opened to extinguish the lamp.

◀ Two drive motors for the first semicontinuous hot strip steel mill on the West Coast are shown being prepared for testing. Rated at 5,000-horsepower each, the motors are part of the equipment being supplied by General Electric for the new Kaiser steel plant at Fontana, Calif. This will be the first hot strip steel mill in the country to use rectifiers alone for converting the alternating current supplied to the mill to the direct current required by the huge drive motors.

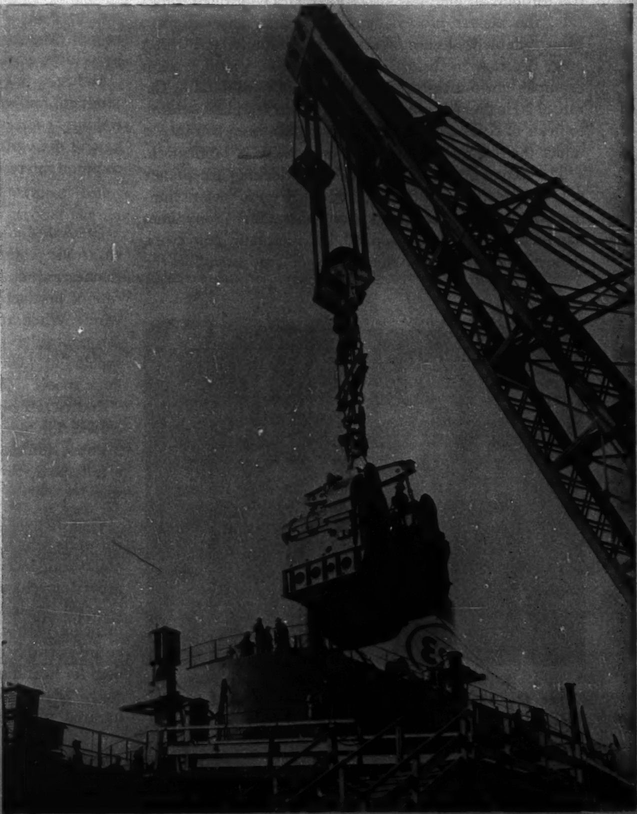
◀ Replacing all old trolley cars, 190 new trolley coaches were placed in service in San Francisco, July 3. Driven by Westinghouse 140-horsepower series motors, the equipment has dynamic braking to enable coaches to run on San Francisco hills.



▲ The first measuring instrument using radioactive isotopes, the Beta Gauge, produced by Tracerlab, Inc., consists of a source of beta radiation and a radiation detector. The material to be measured is placed between source and detector and the radiation is absorbed in proportion to the sample's weight per unit area.



▲ Elimination of jerky starts and stops on trolleys is accomplished with this barrel-like accelerator. In accelerating, the X-shaped arm revolves, the wheels press on the 99 contacts in rapid succession, and power is fed to the driving motors in steps so close together it seems like a steady surge. In braking the process is reversed and the trolley slows quickly and smoothly. This is a development of the Westinghouse Electric Corporation.



▶ This double-reduction gear unit is being swung aboard one of the many new tankers now in production in American yards. A General Electric marine installation, it is designed to harness the driving power of a 12,500-horsepower cross-compound turbine. The unit, weighing more than 175,000 pounds, translates the high speed of the turbines into the relatively low speed (112 rpm) of the propeller. The tanker is one of ten being built for the Standard Oil Company of New Jersey at Newport News Shipbuilding and Dry Dock Company Yards in Newport News, Va.

(*Continued from page 11*)

Radiant Heating. The 1949 development most worthy of mention in this field is the introduction of glassless sheathed resistance radiators with associated optical equipment for industrial heating applications.

Sheathed electric heaters operating at radiating temperatures are ideally suited to water evaporation and other processing applications requiring service temperatures from 200 to 700 degrees Fahrenheit. They are extremely rugged, require little maintenance, and when used in controlled temperature atmospheres will deliver as much as two-thirds of the total input energy in the form of radiation while providing upwards of 6,000 hours service life. Energy densities for these heaters range from 30 to 50 watts per square inch and heat transfer rates of 4,500 Btu per square foot per hour to the working plane are attainable.

ELECTRIC WELDING

In electric welding, notable technical developments were the wide commercial acceptance of the Aircomatic arc welder and the multitransformer resistance welder.

The Aircomatic is a logical step in arc welding. Original arcs in air were followed by shielding the molten metal with gases derived from coatings on the welding rods; and then by inert gases blown into the work. By feeding the welding rod through an inert-gas atmosphere at a controlled, rapid rate, the newest process enters almost a new category. More reliable welds are produced more rapidly, and with a great decrease in distortion of the welded piece. As an example, one-fourth-inch aluminum can be welded at the rate of 30 inches per minute. This progress admits welding to fields of construction that hitherto have been considered under the sole jurisdiction of other methods of fabrication.

The second development is the ever-widening acceptance of spot welders by which parts requiring up to several hundred welds can be assembled in one operation. Sometimes hand-fed, other times supplied by automatic conveyors, these machines extend to the welding of large assemblies the high speeds that have been met for many years by dial-feed welders in fabricating small parts.

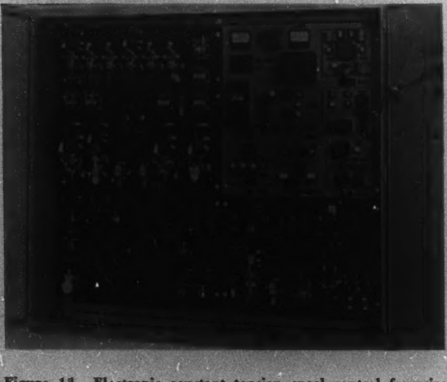


Figure 13. Electronic constant tension spool control for wire drawing machine

Figure 14. New 2-magnet d-c industrial brake

The machine takes the form of a specialized punch-press frame fitted up with many welding points that are fed from numerous small transformers located nearby to minimize the difficult electrical problems accompanying the use of currents in tens of thousands of amperes. Originally adopted for high production jobs in the automotive industry, this principle is now being used in other fields where the rate of production justifies the relatively heavy investment in welding equipment.

Industry has awakened to the advantage of designing products for welding operations. This has led to more welding courses in schools, and to greater co-operation among the various different technical societies who have a common interest in welding.

INDUSTRIAL CONTROL

Constant Tension Spooler Control. The development of an electronic constant tension spooler control by Cutler-Hammer, Inc., has permitted a considerable increase in the rate of production in the intermediate drawing of copper wire. When applied to a circular wire drawing machine, the controller permits the finer wires to be drawn and spooled at 4,000 feet per minute and wound on relatively large spools. (See Figure 13.)

Individual plug-in-type electronic control units are included for power supply, regulation, thyratron amplification, automatic stopping of the machine upon reaching a full spool, as well as for remote control of the drawing speed.

Plate Rheostats. A new line of square-shape plate-type rheostats which possess a much higher power dissipating ability, an increased number of resistance steps, and improved mechanical features, has been developed by the General Electric Company. By putting the resistance element on both sides of a mounting plate and encasing the entire assembly in a metal casing, both sides of the plate are used for heat dissipation to the fullest extent. An intensive study of surface temperature distribution by means of infrared photography contributed heavily in raising the

Figure 15. Packaged drive

power dissipating ability to nearly three times its former value. This method was also valuable in selecting the optimum high emissivity finish. Being completely encased in steel, the rheostat is not easily damaged.

Industrial Brakes. A new line of magnetic brakes with increased simplicity and a minimum number of moving parts has been developed by the General Electric Company. Two magnets are used, with the two brake shoes mounted directly on the magnet armatures. A single tension spring connected between the armatures sets the brake. This construction eliminates all cross levers and linkages with the attendant bearings, present in conventional single-magnet brakes. The number of moving assemblies and working bearings is reduced to two.

This design incorporates these improved features: linings replaceable without disassembly of the shoes; self-aligning shoes promoting long lining life; visual indication of torque setting; visual indication of armature gap adjustment; easy torque and lining wear adjustments; watertight coils; and bearings sealed against dirt and moisture. Brakes can be supplied with either shunt or series coils.

A typical brake is illustrated in Figure 14.

Packaged Drive. A packaged drive (Figure 15) which provides speed control of d-c motors from an a-c line with speed ranges of 8 to 1 by armature voltage control and 2 to 1 by field control, and with electronic exciters for motor and generator has been developed by the Westinghouse Electric Corporation.

Applications include: paper industry—winders, pulp washers, shakes, wet machines, cutters, converting machines; machine tools—milling machines, lathes, grinders, gear cutters; textile industry—warpers and beamers, slashers, full fashioned hosiery machines, variable speed spinning machines, finishing machines, spoolers; rubber industry—bias cutters, tread cutters, tread conveyors, extruders, and tubers.

Register Regulator. A register regulator with photoelectric register control complete with combination transmitted and reflected light scanner was specially designed by the Westinghouse Electric Corporation for the package wrapping industry. It provides one way register control and will maintain accuracies to plus or minus 1/32 inch even with line voltage fluctuations of ten per cent above or below normal at speeds up to 300 packages per minute. Any type of wrapping material such as cellophane, waxed paper, metal foil, or cloth may be used and the change from transmitted to reflected light operation is made by flipping a switch on the regulator panel. The regulator is wholly industrial and is contained in a dust-resistant cabinet. Connections between the regulator and scanner are plug-in locking-type armored cables.

Synthetic Sound on Film

Music without musicians is in prospect for movie audiences of the future. This probably will be the ultimate result of research conducted by Robert E. Lewis, Associate Physicist at the Armour Research Foundation of the Illinois Institute of Technology and Norman McLaren of the National Film Board of Canada. These two men have come up with a technique for recording music on film without the use of any sound recording device whatsoever.

Today's movie sound tracks are made by electronically translating sound into a complex pattern of light and dark areas on film. A light directed through the film onto the surface of a photocell causes the pattern to be retranslated into the sound heard in movie houses.

Film music of the future will require no player-artist. Sound track patterns will be made either by hand or machine. Lewis and McLaren have worked out the mathematics of putting rhythms, pitches, and amplitudes into patterns on a sound track to give back the desired sounds. For example, high C on a violin is represented by a special shape in the pattern. The same note on an organ takes a similar but slightly altered shape. Frequency of recurrence of the pattern determines pitch, and density determines amplitude.

The scientists' first experiments were on hand-drawn sound tracks. Later, they developed a generator, a device with a shutter which exposes the sound track of a film in a given pattern and at specified intervals.

Eventually, with improved electronic devices, it will be possible to duplicate all musical instruments. Further, the scientists envisage the synthesis on film of new musical timbres not now produced by any existing instrument.

Nonlinear Functions in an Analog Computer

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B. N. LOCANTHI

TWO BASIC types of devices for simulating arbitrary functions of a dependent variable have been developed for use with the California Institute of Technology Electric Analog Computer. One of these is a resistance device whose resistance is a function of current. It is based upon the use of germanium diode circuits which switch resistances in or out either to increase or decrease the resistance as the current increases. The other nonlinear device employs the principle of a cathode-ray tube–template-photo cell servo system which makes the cathode-ray beam follow a prescribed curve and thereby produce a voltage which is the arbitrary function of another voltage. Both of these devices can be used to represent perfectly general nonlinear impedances or amplification factors.

In some physical systems a variable exhibits a linear characteristic until it reaches a limiting value which it cannot exceed. Such characteristics can be produced electrically with a voltage limiter if the voltage at some point in the electrical circuit can be made the analog of the variable in the physical system. The only important electrical requirement is that the voltage clipper be driven by a source with high impedance so that the forward resistance of the diode is very small compared with the source impedance. In typical cases the slope of the characteristic may be changed by a factor as large as 2,000. This principle can be used directly to simulate position and velocity stops in servomechanisms, coulomb friction, backlash, and irreversible gears. A current limiter may be used in those cases where the current is analogous to a physical variable which is limited in its maximum value.

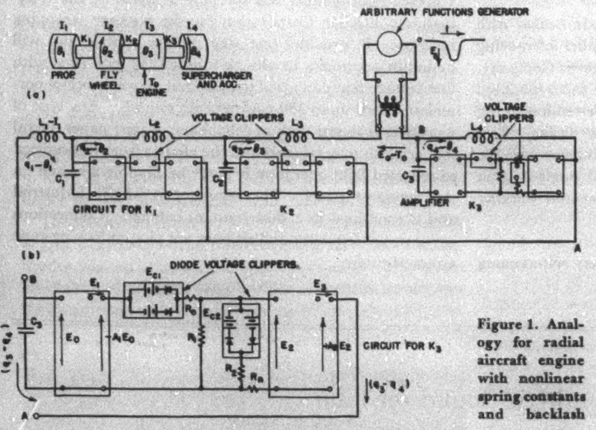

Figure 1. Analogy for radial aircraft engine with nonlinear spring constants and backlash

The application of the nonlinear impedance circuits to mechanical systems with nonlinear springs and spring-loaded backlash is illustrated by the system of Figure 1. This is the rotating mechanical system of radial aircraft engine that was studied quite extensively with the computer. In this system all three shafts are geared and have appreciable spring loaded backlash. In Figure 1, the spring constants K_1 and K_2 are linear except for backlash. However, K_3 has in addition to backlash a sudden change in spring constant at a given stress.

During the past few years, this computer has been used extensively for the design analysis of guided missile control systems. In most of these studies the aerodynamical equations have been linearized but some have included the effects of angle of attack and interaction between the three degrees of freedom of the missile. The latter type have included studies of "stabilized" platforms.

Several types of servomotors have been analyzed. One of the most important of the nonlinear motors studied extensively is the "rate limited" hydraulic motor. In this, a hydraulic valve is actuated, usually by an electromagnetic solenoid circuit. The valve controls the flow of the hydraulic line which will drive the missile control surfaces in either direction at a velocity proportional to the valve opening. However, the maximum control surface velocity is limited to a value corresponding to the full open position of the valve. The nonlinearities in motors of this type can usually be accurately specified by assigning definite maximum values to the rudder velocity and rudder position and assuming the system to be linear below these limits. Position control is obtained by the use of feedback from the rudder position.

These limits are accomplished with two voltage clippers. It was found that the velocity limitations for some motors had a saturation characteristic which was not perfectly flat. This type of characteristic was studied by using an arbitrary functions device instead of the simple voltage clipper. The study showed that sufficiently accurate results could always be obtained with the simple voltage clipper.

Digest of paper 49-165, "Application of the California Institute of Technology Computer to Nonlinear Mechanics and Servomechanisms," recommended by the AIEE Computing Devices Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Erythemal Intensity Meter

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THE INCREASING USE of sunlamps by the public and the interest shown in sun tan evidenced a need for a compact, rugged, portable erythemal intensity meter. The intention was not to develop a meter of laboratory precision, but to furnish a reasonable accurate commercial tool that could be used in the field as a guide to relative intensities in the 2,800- to 3,200-Angstrom unit band.

A unit has been developed utilizing the broad principle of pre filter, exciter, post filter, and meter. The pre-filter comprises two filter glasses. The exciter is a tungstate phosphor that converts certain portions of the ultraviolet to light at the same time acting as a neutral filter to other portions of the spectrum. The post-filter comprises a plastic and glass combination absorbing some wave lengths and transmitting others to the barrier layer cell, which is connected to the recorder or meter proper.

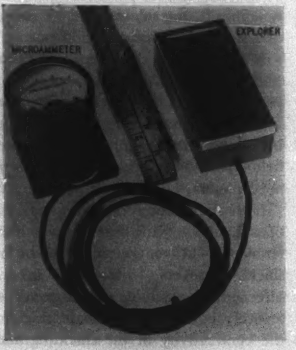

Figure 1. Microammeter and explorer

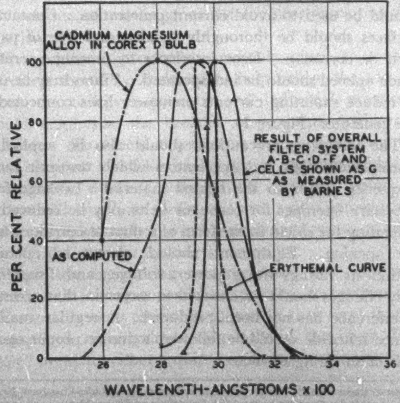

Figure 2. Over-all spectral response of meter to erythemal curve; for comparison, response of cadmium magnesium alloy phototube is shown

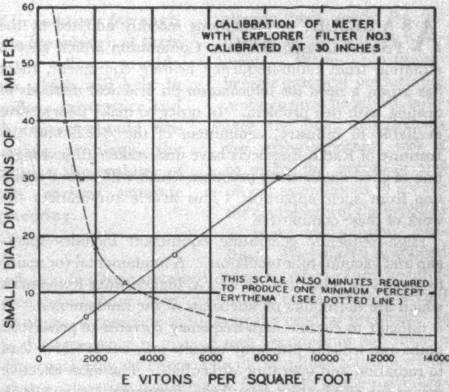

Figure 3. Typical calibration showing linearity also time in minutes versus intensity to obtain one minimum perceptible erythema

E-Viton: A unit employed to express the health and erythema value of radiations above 2,800 Angstrom units, such as found in natural sunlight, while erythemal flux is that quantity of radiant energy which produces as much temporary reddening as 10 microwatts of energy at 2,967 Angstroms. One E-Viton per square foot is the same as 0.01 erythemally-weighted milliwatts per square foot or 0.01076 erythemally-weighted microwatts per square centimeter

The spectral response follows the erythemal curve closely enough for practical purposes and has the advantage of reading directly without the necessity of using weighting factors. The development has resolved itself into meters of two sizes. One of these is approximately $2^1/_2 \times 3^1/_2 \times$ 1 inches, about the size of a pocket light meter. This uses a filter and single barrier layer cell. The other uses four barrier layer cells and filter in conjunction with an optical system for use in a solarium. It projects on the screen the time in minutes that will give an exposure of one minimum perceptible erythema at that particular location. (In most solaria the erythemal intensity is not uniform throughout the irradiated area.) A similar device could well be used at beach resorts as a companion instrument to the temperature indicator. Such an intensity meter would have a large moving hand which would give an indication in minutes for exposure of one minimum perceptible erythemal for that particular time of day.

Digest of paper 49-168, "Measurements of Erythemal Energy," recommended by the AIEE Committee on Production and Application of Light and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Reducing Radiation From Heating Equipment

G. W. KLINGAMAN

AS A RESULT of regulations recently adopted by the Federal Communications Commission which govern radiation from radio-frequency heating equipment, there has arisen a need for information on practical methods of dealing with this problem. In order to make information available to industry, committees of the AIEE and the Institute of Radio Engineers have undertaken an investigation of good engineering practices which will reduce radiation from such apparatus. This article summarizes the work of these committees.

High-frequency generating equipment includes spark-gap and vacuum tube oscillators. A fundamental (or main) frequency is generated, as well as higher-order frequencies which are harmonics or sidebands of the fundamental. It is difficult to confine high-frequency currents to prescribed paths and leakage into stray circuits may occur which lead to radiation and operating difficulties. The most effective means for eliminating stray radio-frequency currents is to surround each part, or the whole of the installation with a good shield of high-conductivity metal.

Frame currents, along the edges and over the surfaces of metallic enclosures surrounding the apparatus, are serious sources of radiation. They may be produced by a poorly conducting shield, such as iron screen of large mesh, by openings in the shield to admit conveyor belts, poor joints and slits in the shield, windows, and other openings of one sort or another. Another source of radiation is radio-frequency current flowing in power lines, plumbing, and other conductors attached to the equipment.

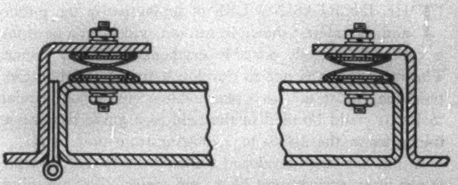

Figure 3. Spring contacting device with clamping strip for bonding doors

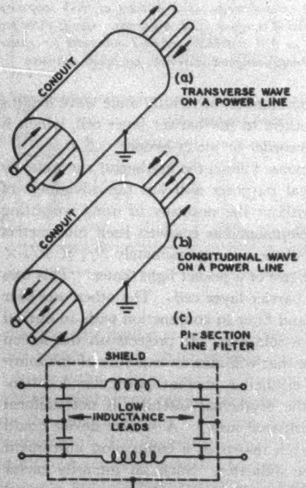

Figure 1. Stray currents on a power line and a filter for eliminating them

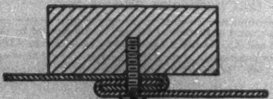

Figure 2. Shield joint formed by locking two metal sheets and attaching to the supporting frame

Various detecting devices are available for locating and measuring the magnitudes of radiation. These include field strength meters, radio-frequency current probes, and noise meters.

Both manufacturers and users of equipment must co-operate in observing practices which will minimize the interference. The generator should be housed in an effective shield. Louvers, windows, or other openings should be screened, if possible, the edges of such screening being securely bonded to the main shield. Plating to improve the conductivity of the shielding and the corrosion-resistance of joints is advisable. Sufficient thickness of metal should be used to avoid current penetration. Contacting surfaces should be thoroughly bonded and free of paint, dirt, or corrosion. Door interlocks to prevent operation when opened should be incorporated. Filters may be used to reduce radiating currents on power lines connected to the generator (Figure 1).

The foregoing precautions should also be applied to transmission lines and applicators which transmit radio-frequency power to the heated material. Leakage from necessary openings for conveyor belts may be reduced by extending the shield in the form of a duct or corridor about the opening. Equipment should always be operated within its ratings as to power, voltage, and frequency. Any changes should be checked to ascertain that excessive interference has not been produced. A regular maintenance schedule should be followed to insure proper operation of shielding devices.

Digest of paper 49-182, "Reduction of Interference From Radio-Frequency Heating Equipment," recommended by the AIEE Committee on Electric Heating and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Design Problems for Engineering Education

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With the increasing need in industry for engineers with a comprehensive knowledge of their field, it is important that the colleges provide senior engineering courses which will help to bridge the gap between college experience and industrial practice. Such courses should emphasize practical engineering problems, the solution of which will require the making of assumptions involving the various separate fields of engineering.

AS THE enrollment in colleges of engineering has increased, the problem of providing effective engineering education has become much more difficult to solve. The very magnitude of the task has forced the colleges to specialize in much the same way that modern industry has done to meet the need for the large volume of industrial products. Thus, the average college student receives instruction in mathematics by a specialist in this field, training in physics by experts in physics, and is expected to gain his knowledge of English from those who have made its study their life work. The educational profile of a typical engineering student, consequently, consists of peaks and valleys in proportion to the specialized course instruction he has received. It is hardly surprising, therefore, that he is well equipped to solve complicated problems in a particular area such as mathematics or physics alone, but is not capable of solving simpler problems involving several fields.

On the other hand, industry is becoming more and more conscious of its need for men with a comprehensive knowledge of engineering, with an ability to solve a comprehensive engineering problem. It is significant that the need for such an all-around engineer is even greater in smaller companies because such concerns can ill afford to permit the degree of specialization which the larger companies may tolerate or encourage as the engineer gains practical experience in industry.

The engineering courses commonly given to seniors, therefore, should be designed to help bridge the gap between the college experience and industrial practice—should emphasize the breadth of practical engineering problems. To solve such problems the practicing engineer must integrate all of his knowledge of separate fields into an effective working combination. At this point the student will usually be confronted with a situation which he has not experienced before in his specialized course training, namely, the need for making assumptions.

When the engineering undergraduate has been concerned with solving a particular problem in mathematics it has usually been presented to him in such form that no assumptions are required. Similarly in the other fields "type" problems either require no assumptions or they have already been made for the student in the problem statement. When a comprehensive practical engineering problem must be solved, however, the first, and perhaps the most important task is to make the necessary and proper assumptions to reduce the complexity of the problem to make its solution possible. After such a simplified solution has been obtained, then the effect of the assumptions which have been made must be carefully analyzed to obtain a complete solution to the original problem. It is this experience in making such assumptions and then in later analyzing the effect upon the simplified solution which most engineering students lack as a result of the specialization of engineering education. By their very nature such practical engineering problems, even in electrical engineering, will involve not only principles of electricity, but also the fundamentals of mechanics, heat transfer, fluid flow, and many others.

Illustrative of the type of design problem with which engineers in industry are confronted are those stated in the following. As these problems are real design problems, they are not applicable for undergraduate assignments directly although they can be broken into component parts which may be. Each is naturally a problem requiring much time to obtain the essential preliminary familiarity before a mathematical solution can be attempted. Such problems can be effectively used only in a senior course in which a few problems are assigned with several weeks allowed for the discussion and solution of each. Such a course would be much like a series of very minor theses. Its values, as a preparation for a job in industry, would be great.

PROBLEMS

Problem 1. Pressure Distribution in a Cooling Duct

Turbine-driven alternators are cooled by air flowing through horizontal slots in the rotor. The slots which are cut in both ends of the rotor are covered for part of their length and pierced by openings into the air gap for the rest of their length. The openings consist of a number of holes drilled into the covering wedge. Pressure is supplied at each end of the rotor by the fan action of the rotor's angular velocity.

In design it is necessary to determine the cooling effect and hence the static pressure distribution and velocity

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Essentially full text of a conference paper, "Design Problems for Engineering Education," presented at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949.

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throughout the length of the duct. Of particular importance is the point at which the flow velocity reduces to zero, as this determines the practical length of the duct. In any particular suggested design the shape of the slots and the size of the ventilating holes is known. By test, the static pressure ahead of the slot opening where there is negligible air velocity and the static pressure at the beginning of the ventilating holes, a given distance from the rotor ends, are also known.

With a competent and stimulating instructor, and in a senior class with proper fundamental background, this problem could well occupy several weeks of study and include exploration of the field of fluid flow.

In order to illustrate the importance of making proper assumptions and applying the correct fundamental principles, we have selected this one problem for extended discussion. This problem is of particular interest because it involves principles of fluid mechanics somewhat foreign to the interest of the electrical engineer and yet the solution to such problems is essential in the design of electric equipment such as turbine-driven alternators.

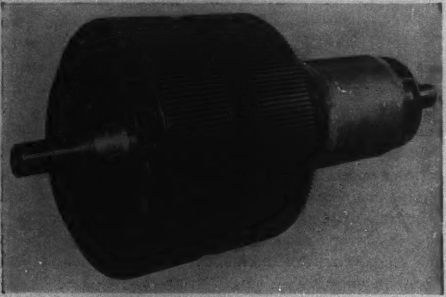

Figure 1. Shrunk-fit rotor for a single-phase inductor generator with a 75-kva (maximum) 3,600-rpm 440- and 220-volt 9,600-cycle rating

Problem Analysis. This particular design problem requires an unusual number of assumptions to obtain numerical values. Before such assumptions can be made, a general appreciation of the physical principles involved and the behavior of the air flow is essential.

As the air enters the cooling ducts from each end, the static pressure falls as the flow velocity increases in accordance with simple energy equation of flow (Bernoulli) until the air reaches the first hole. At each successive hole the main duct flow loses energy and momentum by the amount of the energy and momentum in the air blown out. The quantity of air flow in the duct is also reduced. From conservation of energy and momentum, the static air pressure at successive holes will gradually rise as the flow velocity reduces to zero.

The major assumptions that are necessary to make numerical calculations are based on the following considerations. Although the flow of air will be affected by centrifugal forces exerted on the air in the duct, we will first neglect such forces as they affect pressure and velocity distribution within the duct and flow through the ventilating holes. To use energy considerations we must assume negligible turbulence and friction. In preliminary calculations it is also desirable to neglect the variation of velocity across the duct and the ventilating holes. In other words, the effect of viscosity is neglected. Since the pressure changes are small compared with atmospheric pressure, the variation in density will be small and the fluid should be assumed incompressible. The effect of the sides of the orifice in changing the momentum of the air is assumed insignificant.

Simplifying the problem with such assumptions it is now possible to write momentum and energy equations, relating the pressure and velocity in the duct before and after each hole and the pressure and velocity of the air passing through the hole. Since the momentum of the air must be conserved, the air leaving each hole will have an axial component as well as a radial one.

Having made such assumptions and obtained a first approximation, then the effect of each assumption on the result should be calculated in so far as possible. Finally, tests should be used to substantiate calculated results. For example, the flow of air through an orifice such as those in this problem could be set up in test and calculated results compared with test directly. In estimating the effect of neglecting friction similar tests could be made on lengths of duct to determine the order of magnitude of friction losses.

Typical parameters in such a problem are as follows: duct height—2 inches; width—0.75 inch; hole diameters—0.375 inch; distance between hole centers—1 inch; pressure ahead of duct (negligible air velocity)—5 inches of water; pressure at beginning of holes—3.5 inches of water; distance from the duct inlet to the first hole center—24 inches.

Problem 2. Stresses in Shrink-Fit Rotors

In the design of motors and generators in which the rotor is shrunk on the shaft, it is important that the rotor stresses be less than the elastic limit of the material and that the rotor not slip on the shaft at any speed and torque to be encountered.

Therefore, the questions to be answered are: What are the stresses at the fit when a rotor hub is shrunk on a shaft in terms of speed, interference fit, and dimensions of hub; what is the torque that may be transmitted by the friction of the fit? Consider solid steel hubs having diameter up to three times the diameter of the shaft and length up to the equal of the diameter.

An initial solution to this problem can be obtained by setting up equations for the radial and tangential stresses in terms of the radial and axial deformations. Equations of equilibrium for a differential element can be set up also and a combination of these equations will produce solutions for the stresses. The torque which can be transmitted is determined by finding the radial force at the fit and multiplying it by the fit radius and the coefficient of friction between the shaft and rotor.

To approach the problem in this manner it is necessary to assume, among other things, that the strains vary only with radius except axial strain which is assumed constant with radius, resulting in plane strain only, and that end effects are neglected. Examination of the effect of assumptions will undoubtedly show that the assumption of no axial slippage during shrinkage, if such an assumption is made, is not valid.

Problem 3. Current Distribution in Solid Conductors

What is the current density along the top and bottom of solid amortisseur winding bars in the rotor of a turbine generator and what is the current density in the top of the solid steel rotor teeth when load current at zero power factor is changing at a rate of ten times full load amperes per cycle?

This is a transformer circuit problem and can be solved by setting up an equivalent circuit. It is assumed that the amortisseur bars and rotor teeth are equivalent to stranded conductors with one strand above the other in the radial direction of the rotor. It can be assumed for a first solution that resistance and reactance of the end connections are negligible. Then the windings may be treated as nested circuits all concentric with the pole axis. The mutual and leakage reactances and the resistances of each strand are calculated and entered properly in the circuit diagram. The resulting circuit can be solved by calculation but preferably it should be set up on a network analyzer so that the currents in the branches may be metered. The ratio of each current to each strand area, respectively, gives the desired current densities.

Problem 4. Surge Current and Torque in D-C Machines

What is the maximum shaft torque a d-c motor or generator must withstand if an accidental line-to-line short circuit occurs and what maximum current must the circuit breaker interrupt when it operates in 1/120 second? When it operates in 1/30 second?

For a first solution, magnetic saturation may be neglected. An equation for the armature circuit may be written assuming there is no external impedance, equating the sum of the resistance drop, the inductance drop, and the drop equivalent to the a-c reactance drop of the armature winding, to the electromotive force generated by the field excitation. To determine the drop equivalent to reactance voltage it can be assumed that volt-amperes squared lost at the brush contacts in any period is equal to the total change in inductive energy of the armature coils during current reversals for the same period.

This assumes that the brushes are 100 per cent efficient and that no electromotive force is generated in the coils during the first 1/30 second other than by self-induction. The validity of the assumptions must be proved later by comparison of calculated results with test results. A solution can now be obtained by assuming the electromotive force generated by field excitation remains constant for the short time of 1/30 second. However, such an assumption would not be consistent with the assumption for the equivalent reactance voltage which implies that the current will shift in the brush contacts toward the trailing edges of the brushes. Thus it is more logical to assume that the axis of armature reaction shifts substantially half the width of the brush. This introduces a magnetomotive force acting to oppose the field magnetomotive force. To handle this condition it is necessary to assume that the total flux linkages of the field circuit remain constant during the 1/30 second period. Then the sum of the flux linkages due to flux generating armature electromotive force and the linkages due to other flux (leakage flux) after short circuit

Figure 2. A 1,000-kw 600-rpm d-c machine on test under severe momentary overload producing high stress on windings and mechanical parts

can be equated to flux linkages before short circuit. A solution can be derived from the two simultaneous equations. Tests are required to determine the accuracy of the solutions.

Problem 5. Forces on Windings Tending to Strain the Insulation

What are the force and shearing stresses acting on the insulation on the end turns of the armature winding of a turbine generator per unit of current?

This requires a determination of the flux field in which the conductor lies. The variation of the field strength and the conductor current with respect to each other must be determined in order to determine the maximum force. Moreover, this must be determined for balanced 3-phase currents and single-phase line-to-line and line-to-neutral currents.

Logical and justifiable assumptions must be made to settle the influence of neighboring magnetic materials, eddy currents in conducting materials, and to eliminate a third dimension from field determinations.

The solution requires knowledge of synchronous machines, harmonic alternating currents, electromagnetic field mapping or calculation, and statics. Mathematics through partial differential equations is required including knowledge of field equations.

Problem 6. Proportions of Double Squirrel-Cage Induction Motor Rotor Windings

What are the most desirable ratios of bottom bar resistance and reactance to top bar resistance for the double squirrel-cage winding in a 3-phase induction motor, so that the increase in starting over running resistance is a maximum at a chosen slip, s, keeping fixed values for the running resistance and the maximum torque of the motor?

To solve this problem, it is convenient to form the equivalent circuit for the motor, including the separate squirrel-cage bars and a common end ring, and to derive exact expressions for the combined squirrel-cage resistance, R, and reactance, X, at any slip, s, in terms of the running values of resistance, R_0, and reactance, X_0, which hold at very small values of slip. By differentiating the expression for R so obtained, with fixed values of R_0 and X_0, the desired values of individual bar impedances can be determined.

It is desirable to carry the problem through by finding the bar and slot dimensions required in the case of an actual motor. Care should be taken that the leakage slot for flux passing between the upper and lower bars be wide enough to prevent magnetic saturation when starting under full voltage.

Problem 7. Temperature Distribution in Armature Windings and in Turbine Generator Field Windings

Radial temperature distribution in a turbine generator field winding at steady state is an important part of the picture of winding distortion under fluctuating load. The usual winding construction consists of a number of turns insulated from each other and from the rotor iron. Cooling is provided by utilizing air or hydrogen flowing in the gap, and sometimes also flowing in ventilating tunnels and in subslots.

The method of attack is to set up a thermal circuit in which heat flow corresponds to current, temperature to voltage, and thermal resistance to electrical resistance. Heat is generated in a certain geometrical configuration and is dissipated by several means. All the cooling is eventually done by the cooling gas, so the several paths of heat flow to the gas are established, and the thermal resistances of these paths evaluated. Heat flows to the gap directly through insulation and wedge and also to the gas at the pole face by conduction through the rotor body. It flows to the ventilating tunnels and subslots.

Determining the magnitudes of the resistances means determining thermal conductivity of the insulation, wedges, and rotor iron; forced convection coefficients of heat transfer for fluids inside ducts and for rotating surfaces; flux plot for conduction to pole face. These resistances are put into the thermal circuit together with the heat gener-

Figure 3. Section of wound stationary armature of an a-c water-wheel generator with a rating of 75,000 kva, 138.5 rpm, 13,800 volts, 60 cycles

ated, and the temperature rise of the copper is determined. A uniform copper loss is first assumed and then this loss is subsequently corrected for nonuniform temperature distribution.

The distribution of temperature in armature windings of rotating machines can be solved by dividing the winding into sections for each of which it can be assumed that all heat flow is in a radial plane. The sections are so chosen that within each the heat flow paths are homogenous and the losses are uniformly distributed. On this basis the end windings may be taken as separate sections, the central core portion of the winding as another section, and the end core portions where the core losses are larger, and where end effects must eventually be allowed for, as other sections. From this point on the method is the same as in the case of the turbine generator field windings. The determination of distribution of copper and iron losses including stray losses which must be made beforehand is a complex problem. With respect to these problems test results are indispensable, but when used without calculations are not adequate for advanced design work.

CONCLUSIONS

Problems similar to these seven are legion in all classes of machinery. For example, the problems mentioned in an article recently published in *Electrical Engineering* entitled "Is There a Doctor In The House?"[1] require the same type of approach. All real design problems are of the thesis type. When separated into component parts so that each part is limited to the subject matter of one of the courses into which engineering education is customarily divided, the resulting little problems are no longer representative of real design problems. Although rotating machines have been used exclusively for the problems, the scope of the problems in all classes of machinery is as broad.

Solution of such problems will develop in students an ability to solve comprehensive engineering problems and a feeling of confidence in their ability to solve such problems and others which are entirely new to their experience. It is the method of attack upon such a problem which is important—the searching mental effort which must be devoted to such a problem before a single equation is written or any calculations are made. To be most effective and realistic any engineering problem given should be so selected that of the total time required for its solution 80 or 90 per cent should be spent in "mulling it over," and only 10 or 20 per cent in working out the solution on paper. The use of such problems puts a very heavy burden on the engineering faculty because no "standard solution" can or should be prepared, and problems should be changed frequently, perhaps even to the extent of using different ones every year. However, where the use of routine "type" problems will merely provide an exercise in calculation and mathematical manipulation, the use of such comprehensive problems will develop to a significant degree real engineering ability in the student.

We must also appreciate that the use of comprehensive problems in a college course will require a considerable amount of time in home study—much more than the usual college course. We do not see any possibility of reducing such time, however, without destroying the most important part in the solving of such problems, namely, the time spent in "sparring" with the problem before attempting its formal solution.

Industry is anxious to help the colleges to correct the erroneous ideas of many students concerning the design function in industry. Too many look upon design as the process of making routine calculations to adapt standard designs to slightly different uses and needs. That this is not the case in industry is indicated by the degree to which such calculations are made by engineering assistants or by persons without complete technical training. Correspondingly, the pressure of industry upon the colleges is more and more to have them provide engineering graduates with the ability to solve the many unsolved problems of industry.

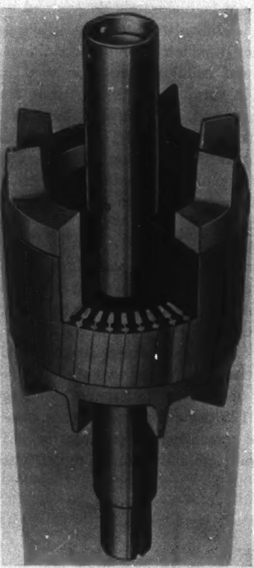

Figure 4. Cutaway quarter section of a double squirrel-cage rotor for a hollow shaft vertical induction motor

The job of industry is essentially the job of production—the production of goods which people want at prices they can afford to pay. Industry must, therefore, measure the value of its manpower against what that manpower can accomplish in improving production through lower cost or improved design. We must have engineers, therefore, who have the knowledge, imagination, and vision required to produce such new products and devices; knowledge, imagination, and vision which is not limited to any one particular kind of engineering but which ranges over the whole field.

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Life Testing of Power Transformers

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MOISTURE and oxygen in varying amounts are the ever-present enemies to the satisfactory operation of liquid-immersed transformers. The life of the oil and insulation in a transformer cannot be accurately determined by laboratory tests since it is difficult, if not impossible, to make such tests so that they duplicate operating conditions.

Protection of the oil and cellulose insulation used in transformers is afforded in varying degrees by what are termed free-breathing, restricted, or controlled breathing and completely sealed-tank construction. Thus, in order to determine under actual operating conditions the effects of different forms of protection on oil-immersed transformers, a group of 14 power transformers has been under life test operation for the past five years.

All of these transformers are installed and operating under outdoor service conditions. Some use sealed-tank construction; some are open air breathing; two are equipped with expansion tanks; others are protected by an inert gas; and four are equipped with clay or alumina filters.

Under the life test, all of these transformers are subjected to identical loading conditions except that two of the transformers are arranged to operate at hottest-spot winding temperatures of 105 and 125 degrees centigrade, as compared to operation of the remaining transformers at 115 degrees centigrade. A complete temperature record has been kept on the operation of each transformer during the entire life test to date. Among other data obtained are records of power factor, acidity, dielectric strength, color, and interfacial tension of the oil in each transformer.

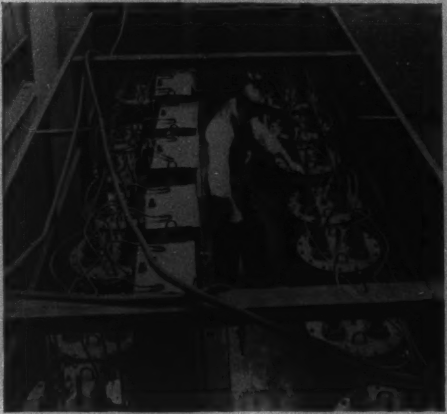

Figure 2. Complete installation of transformers on life test

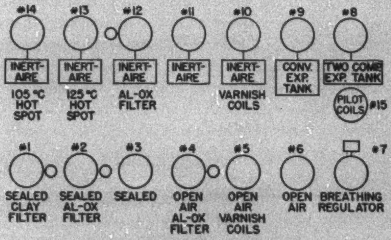

Figure 3. Identification of test transformers

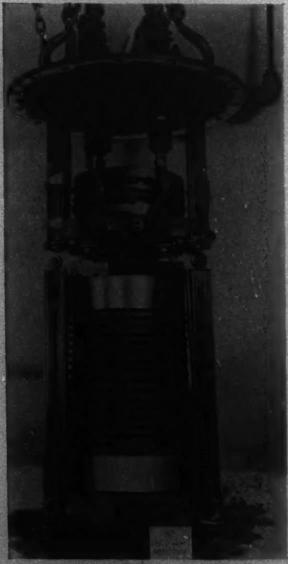

Figure 1. Interior view—life test transformer equipped with open air breather

As a result of the life test of these transformers, it is hoped to show the value of this type of testing under actual operating conditions as compared to short time or accelerated laboratory tests in evaluating the condition of transformer oil and insulation, or in comparing different methods of oil and insulation preservation now in common use.

Digest of paper 49-193, "Controlled Temperature and Insulation Protection in the Operation of Power Transformers," recommended by the AIEE Committee on Transfromers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Economic Loading of a Transformer System

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SINCE 1942 the electrical industry has had an AIEE operating guide for oil-immersed transformers. For proper application to a transformer system it is necessary first to consider whether it is economical to load transformers to the levels recommended by this operating guide.

In an economic study, installation costs and operating costs must be evaluated for various types of load at the levels outlined by the operating guide. Costs must be measured for operation with normal life and also for operation at higher load levels with shortened life. Because of the wide range of installation costs, operating costs, and loading conditions, even on a single system, such a study can best be made on a unit basis with a range of each of the major variables. The results are then applicable to any specific conditions that may confront the user.

The general indication of the study was that present high costs of installation and operation justify economic load levels far beyond the safe thermal levels established in the operating guide.

The operating guide requires proper application to a transformer system. Power transformers on the system being studied are generally operated in parallel groups with the requirement that the load be carried with the highest unit out of service. This establishes both the normal and emergency operating condition with the total load for the group approximately the same in both cases. Both normal and emergency load capabilities must be considered, since either may be the limitation for such a group. In many cases use of auxiliary cooling during emergencies gives the increase in emergency capabilities that is needed to raise the over-all load capability of such transformer groups.

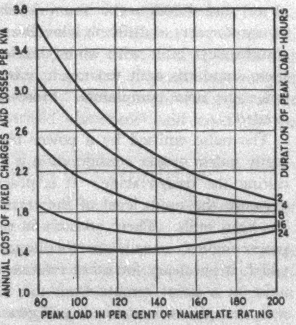

Figure 1. Effect of peak load and peak duration on cost of operation

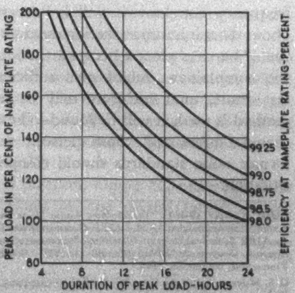

Figure 2. Effect of transformer efficiency on economic peak load

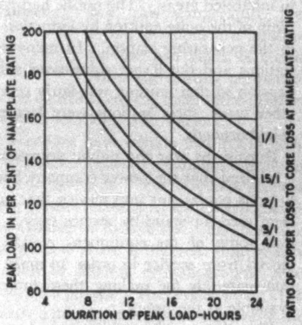

Figure 3. Effect of loss ratio on economic peak load

Effective thermal loading of transformers must include thermal loading of all connected equipment. This must be established by each operating company since there is, as yet, no general operating guide for such miscellaneous equipment.

For distribution transformers, the loading is generally limited by voltage regulation requirements rather than by economic or thermal limitations.

Maximum loading of about a million kilovolt-amperes of substation transformers during the past five years has increased about 25 per cent. Comparable gains have been made with other classes of power transformers. The increase in load level on distribution transformers has been slightly higher but it has been accomplished over a 10-year period.

It is apparent that proper application of the present American Standards Association "Guide for Loading Oil-Immersed Distribution and Power Transformers" can raise the average loading of most transformer systems.

Digest of paper 49-188, "Economic Loading of a Transformer System," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Transformer Audio Noise Problems

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PRIOR TO THE LAST WAR the general public was becoming noise conscious and was insistent that all types of objectionable noises be eliminated. Power companies in the metropolitan area were mostly concerned with the noise emitted by transformers of the distribution size since, in a number of cases, these transformers were installed in inhabited areas. The public had not yet begun to complain of the noise emitted by induction equipment installed in the generating station. In many cases, the generating stations and the larger substations still had room for expansion so that housing was fairly remote from them. In other cases, these stations were located in nonresidential neighborhoods.

During the war the public decreased its demands since it realized that the power company had found it necessary to press equipment into service that normally would have been used for stand-by service only. It was also realized that some of the equipment could not possibly be removed from service in order to make improvements and that materials for making these improvements were not available at the time.

After the war the public again became noise conscious. Furthermore, due to the increased load demands, it has become necessary for the power company to expand its existing stations. At the same time housing programs have been set up and, in a number of instances, large housing developments have been built which were adjacent to these stations.

Economics demands that the additional power transformers needed in the expansion programs be of the larger sizes and be installed out-of-doors. Furthermore, it has been found economical and sometimes necessary to locate unit substations at the load centers which are in inhabited districts. Thus the power transformer has become the source of noise with which the power engineer is now concerned. There are a number of power engineers already highly concerned with the problem and, as power demands and housing increase, many more will become affected. All power engineers should consider whether they will have a noise problem in the future from transformer installations being made today.

For the power engineer to take an active part in a satisfactory solution of the transformer noise problem, he should review what is known concerning the source of the noise and the characteristics of the human ear. He should then become acquainted with the existing instruments used for measurement of the noise and the present transformer noise standards.

Considerable material has been written on the source of the noise. About eight years ago two papers were presented before the Institute on this subject. It has been fairly well established that transformer noise is due mainly to the change in dimensions of the steel core when it is magnetized. This has been termed magnetostriction. The resulting hum has a fundamental component of twice the supply frequency, and other components of even-numbered multiples such as the fourth, sixth, and so forth.

The American Standards Association has published the characteristics of the human ear for pure tones in the form of curves known as equal loudness contours. These characteristics together with an additional curve based on a group judgment as to what constitutes a certain percentage reduction in the loudness of a sound have been obtained by subjective measurements. Methods have been advanced whereby these same curves can be used for complex sounds.

The noise meter that has been developed for use in the United States is equipped with networks which weigh the components of the noise in accordance with the equal loudness contours for pure tones. The meter indicates the "sound level" of the total noise and is known as a Sound Level Meter. This meter, together with a sound analyzer, have been valuable tools in the measurement of transformer noise.

The National Electrical Manufacturers Association has set up transformer noise standards which specify the method of test and the allowable sound levels for different classes of transformers of different kilovolt-ampere rating. Power transformers built with sound levels in accordance with these standards emit too much noise and they have and will cause noise complaints. More realistic standards are needed.

The noise emitted by a power transformer may prove costly unless proper consideration is given to this problem during the design stage. It is practically impossible to decrease the noise level of the transformer itself once it has been built. There are certain precautions which the power engineer must take at the site so that any construction which is necessary for other reasons will not increase the noise at a point remote from the transformer. Once a noise complaint does arise it will generally be found that a reduction in the noise of at least ten decibels in the offending frequency components will be necessary, because this is about the minimum reduction that can be appreciated. The use of barriers placed between the source of the noise and the complainant might give sufficient reduction. As a last resort, total enclosure may be necessary. Whatever method is used, it will be found to be costly. Transformer manufacturers and those persons responsible for transformer noise standards should co-operate to alleviate the situation.

Digest of paper 49-191, "Transformer Audio Noise Problems on an Electric Power System," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Structure and Properties of the Permanent Magnet Alloys

ALFRED H. GEISLER

This is the third article in a series* on the theory of magnetism. Dr. Geisler tells of the reactions occurring in the formation of permanent magnet alloys and describes the properties of the alloys during and after formation.

IT IS AN OLD NOTION that high coercivity in ferromagnetic materials is associated with high internal stresses. Coldworking, quench hardening, and precipitation hardening have been known or suspected sources of residual stresses and they have been generally found to be responsible for increased coercive force. However, no quantitative correlation has yet been possible since the stresses or their counterpart, the reaction strains, have only recently been identified in a specific manner.

A formidable number of permanent magnet alloys have been developed in the past few years as listed in Figure 1. Here the alloys are arranged in order of increasing coercive force. While the residual induction varies from 550 for Silmanal to 12,000 for Alnico 5, the coercive force may vary from practically zero for a soft magnetic material to 40 oersteds for a quench-hardened plain carbon steel to over 6,000 oersteds for precipitation-hardened Silmanal. In the present report, some factors regarding structure which will facilitate an understanding of the effects of composition and heat treatment on the properties of permanent magnet materials will be presented. Other features of permanent magnets are summarized elsewhere[1] and need not be repeated.

REACTIONS IN SOLID SOLUTIONS

The permanent magnet alloys are all solid solutions of two or more component metals; further, these solid solutions undergo a change in constitution as they are cooled according to one of the three basic types of reactions illustrated by Figure 2. In the eutectoid reaction which is responsible for the hardening of steels, a solid solution decomposes into two new phases. These have compositions and crystal structures different from each other and different from the parent phase stable at high temperatures. In the second type of reaction, the precipitation of a new phase occurs within the parent solid solution or matrix, which changes in composition. The new phase may be either an intermetallic compound as in the drawing on the left of Figure 2*B* or it may be a solid solution in another metal as on the right of Figure 2*B*.

In the third type of reaction, Figure 2*C*, ordering of the solute and solvent atoms on the crystal lattice occurs. Above a certain temperature the atoms occupy the lattice sites at random whereas below this temperature preferred positions are assumed by the two kinds of atoms. All of the existing permanent magnet alloys can be classified among these three primary types of reaction in solid solutions as in Table I.

Table I. Permanent Magnet Alloys and Percentage Composition Classified According to Solid Solution

Reaction Involved	
Eutectoid Decomposition (Quench Hardening)	
Plain carbon steel	1 C, 0.5 Mn, bal. Fe
Tungsten steel	5 W, 1 C, bal. Fe
Cobalt steel	36 Co, 3.5 Cr, 3 W, 1 C bal. Fe
Precipitation From Supersaturated Solid Solution (Age Hardening)	
Comol	12 Co, 17 Mo, bal. Fe
Nickel-Gold	
Cunico	50 Cu, 21 Ni, 29 Co
Cunife	60 Cu, 20 Ni, 20 Fe
Alnico 3	12 Al, 25 Ni, bal. Fe
Alnico 1	12 Al, 20 Ni, 5 Co, bal. Fe
Alnico 4	12 Al, 28 Ni, 5 Co, bal. Fe
Alnico 5	8 Al, 14 Ni, 24 Co, 3 Cu, bal. Fe
Alnico 2	10 Al, 17 Ni, 12.5 Co, 6 Cu, bal. Fe
Alnico 12	6 Al, 18 Ni, 35 Co, 8 Ti, bal. Fe
Alnico 6	8 Al, 15 Ni, 24 Co, 3 Cu, 1.3 Ti, bal. Fe
Silmanal	86.8 Ag, 8.8 Mn, 4.4 Al
Vectolite	30 Fe_2O_3, 44 Fe_3O_4, 26 Co_2O_3
Superlattice Formation (Order Hardening)	
Nickel-Manganese	
Vicalloy 1	52 Co, 38.5 Fe, 9.5 V
Vicalloy 2	52 Co, 35 Fe, 13 V
Cobalt-Platinum	22 Co, 78 Pt
Iron-Platinum	23 Fe, 77 Pt

The three basic reactions have certain features in common. They are all heterogeneous reactions involving nucleation and growth processes. The reactions progress by nuclei of the new phases forming in the parent matrix and growing at the expense of the matrix. The composition or structure of the new phase is different from that of the matrix; regardless of discrete crystallographic relationships obtained between phases. The crystal lattice in all the new particles bears a definite orientation relative to the matrix lattice. Frequently, particles of the new phase assume a plate-like shape, the principal directions of which are usually, but not always, related to simple crystallographic directions of the parent phase. The anisotropy of shape of these particles may be characteristic of a transition crystal structure in which the crystal lattice of the normal second phase is strained anisotropically. This transition structure and the required strains are considered to be the

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*Previous articles in the series were "Advances in the Theory of Ferromagnetism," R. M. Bozorth (*EE, Jun '49, pp 471–6*), and "Crystal Orientation in Magnetic Alloys," Martin Littmann (*EE, Nov '49, pp 977–9*).

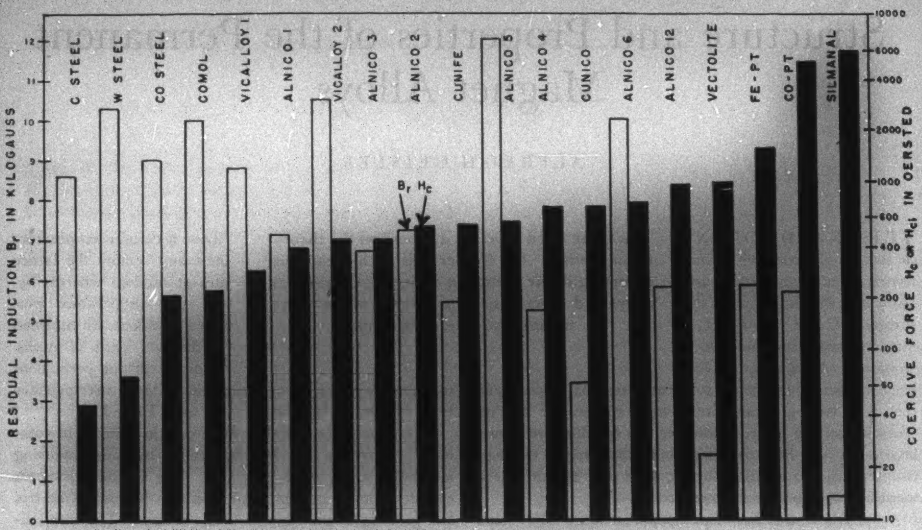

Figure 1. Some properties of the permanent magnet alloys

features of the solid solution reactions important to the development of coercivity.

PROPERTIES OF SOLID SOLUTIONS AND MIXED PHASES

As a foundation for interpreting the property changes that accompany reactions in solid solutions, it is necessary to distinguish between the effects of composition, quantity (in mixtures), and structure of the ferromagnetic phase on the one hand from those of strain on the other. The former are characteristic of the equilibrium constitution of the end products, as shown by the phase diagram, whereas the strain depends upon transient conditions during the reaction. In the absence of any transient effects the properties would change continuously from those of the parent solid solution to those of the end products. The variations of the properties of these phases with composition can be briefly summarized.

It is well known that the addition of most nonferromagnetic metals in solid solution lowers the Curie temperature of the ferromagnetic base metal; it also lowers the magnetic saturation as in Figure 3. The decrease is continuous as solute is added up to the limit of solid solubility (two per cent Cu in Fe in Figure 3). Above this limit two phases coexist in equilibrium and further increase in content of alloying addition results in increasing the amount of the second phase which is a nonmagnetic copper-rich solid solution. On the other hand, the Curie temperature is constant across such a 2-phase region. Thus, while the Curie temperature is a characteristic of only composition (and structure) of the solid solution, the saturation induction depends upon both composition and relative amount of the ferromagnetic phase in 2-phase mixtures. It is interesting to note that the coercive force is independent of composition in solid solution (below two per cent Cu in Figure 3), but in the 2-phase region the coercive force increases rapidly with amount of the nonmagnetic phase. This is an important distinction from the pronounced effect of solid solution additions on physical hardness; it is an exception to the general principle that magnetic hardness and physical hardness parallel each other. The isotropic strains of solid solution formation thus are of little significance in explaining coercivity. It is necessary now to inspect the interaction strains between phases in the 2-phase alloys.

EUTECTOID DECOMPOSITION

The basis of the solid solution reaction for the development of permanent magnet properties in plain carbon, chromium, tungsten, and cobalt alloy steels was illustrated by Figure 2*A*. This is a constitution diagram which indicates that the solid solution in γ-Fe or austenite decomposes on slow cooling below 723 degrees centigrade into ferrite (the solid solution of carbon in α-Fe), and cementite or Fe_3C. The additions of alloying elements such as W, Cr, and Co may alter the reaction temperature and the composition and number of phases. Yet the basic reaction can remain the same.

Hardening of these alloys is not achieved by slow cooling from a temperature in the austenite region but by quenching into water or oil from the high temperature. The reaction is not suppressed by the rapid cooling but progresses into a structure known as martensite. This is illustrated crystallographically by Figure 4. In austenite, the high-temperature form, the carbon atoms assume interstitial positions between Fe atoms on the face-centered cubic lattice while atoms of metallic alloying additions may substitute for Fe

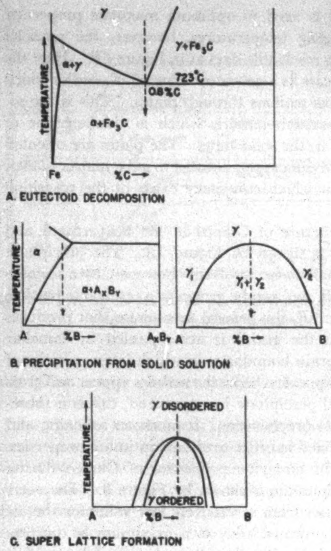
γ
γ+Fe$_3$C
α+γ
723°C
0.8%C
TEMPERATURE
α+Fe$_3$C
Fe
%C→
A. EUTECTOID DECOMPOSITION
α
TEMPERATURE
α+A$_X$B$_Y$
A
%B→
A$_X$B$_Y$
γ
γ$_1$
γ$_1$+γ$_2$
γ$_2$
A
%B→
B
B. PRECIPITATION FROM SOLID SOLUTION
γ DISORDERED
TEMPERATURE
γ ORDERED
A
%B→
B
C. SUPER LATTICE FORMATION

Figure 2. Typical constitution diagrams illustrating the reactions in solid solutions

atoms. The low-temperature form or ferrite is a solid solution based on body-centered cubic α-Fe and has a much lower carbon content than austenite. Quenching from temperatures at which austenite is stable arrests the formation of ferrite in a body-centered tetragonal transition state. Instead of being cubic, the unit cell of the crystal lattice has one edge larger than the other two that are equal. Martensite has been considered to be a supersaturated solid solution of carbon in α-Fe. The lattice parameters of all these structures depend upon carbon content. The *a* parameter of martensite gradually decreases with increasing carbon content relative to that of pure α-Fe while the *c* parameter rapidly increases. Thus, martensite can be considered to be ferrite strained anisotropically by the presence of excess carbon. The counterparts of such strains in other solid solution reactions and their significance in promoting coercivity will become apparent.

PRECIPITATION FROM SOLID SOLUTION

Most of the permanent magnet alloys are of the precipitation type. In Comol the precipitate is a complex intermetallic compound (Figure 2*B*, left) of the approximate composition (Fe, Co)$_3$Mo$_2$, a solid solution between the binary compounds Fe$_3$Mo$_2$ and CoMo which precipitates in a ferrite solid solution. In the other alloys the precipitation process is of a more simple type.

In Cunico and Cunife a continuous series of face-centered cubic solid solutions, γ, extends at high temperatures from Cu to Co or Fe when the Ni content exceeds about 20 per cent as in Figure 2*B* (right). The lattice parameter of the solid solution varies in the usual manner with composition. Thus an alloy, quenched from high temperatures to retain the one-phase solution now supersaturated, will decompose on reheating (that is aging) into two phases with larger and smaller lattice parameters respectively appropriate to the compositions of the new phases, γ_1 and γ_2. This is illustrated by Figure 5 for Cunico. When sufficient time has been allowed for the reaction to progress to completion the structure consists of a copper-rich matrix with a face-centered cubic crystal structure and a lattice parameter larger than the parent matrix plus a cobalt-rich precipitate with a smaller lattice parameter dispersed as particles in the matrix but with the same crystal orientation as the matrix.[8]

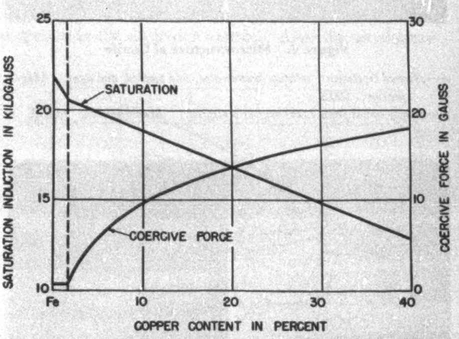

Figure 3. Saturation values and coercive force of Fe-Cu alloys[3]

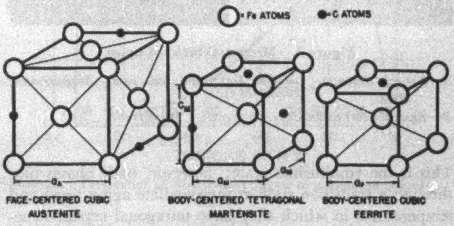
Fe ATOMS
C ATOMS
a$_A$
c$_M$
a$_M$
a$_M$
a$_F$
FACE-CENTERED CUBIC AUSTENITE
BODY-CENTERED TETRAGONAL MARTENSITE
BODY-CENTERED CUBIC FERRITE

Figure 4. Crystal structure of phases involved in eutectoid reaction in Fe-C alloys

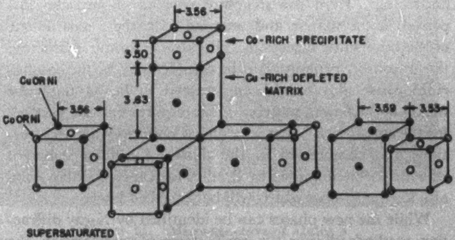
3.56
Co-RICH PRECIPITATE
3.50
Cu-RICH DEPLETED MATRIX
3.63
CuOR Ni
CoOR Ni
3.56
3.59
3.53
SUPERSATURATED MATRIX
COHERENT STATE
EQUILIBRIUM STATE

Figure 5. Crystal structure and orientation of phases involved in precipitation in Cu-Ni-Co alloys[8]

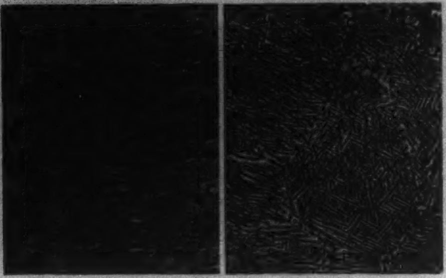

Figure 6. Microstructure of Cunife

A—Normal treatment: solution heat-treated, cold worked, and aged. Magnification: 500X

B—Slowly cooled from 1,080 degrees centigrade. Magnification: 1,000X

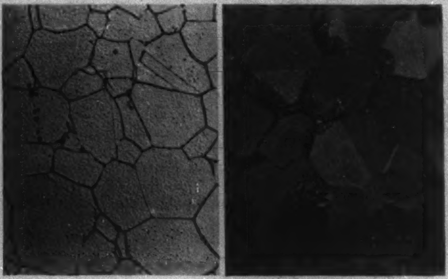

Figure 7. Microstructure of Cunico

A—Normal treatment: solution heat-treated and aged. Magnification: 500X

B—Aged six hours at 800 degrees centigrade. Magnification: 500X

This is the equilibrium state; however, both phases pass through a transition state at intermediate aging times and temperatures in which they have tetragonal crystal structures. The *a* parameters are the same as the parent matrix thus showing that precise atomic matching or registry obtains on cube planes of the parent matrix. This is the coherent state which has been found to be associated with hardening. Here the structure consists of particles dispersed in the matrix and oriented with the *c* axis in one of the three cube directions. Because of atomic matching, the transition structure can be considered to be the equilibrium phase that have been strained to fit on the cube planes of the parent matrix. This requires that the unit cell for the cobalt-rich phase is extended uniformly in two directions and compressed in the third. A similar coherent state has been identified by Bradley for Cu-Ni-Fe alloys and also for the Alnicos which will be described later.

While the new phases can be identified by X-ray diffraction methods during the early stages of precipitation, the particles may be too small to resolve adequately with the microscope. In Figure 6*A* the precipitate in Cunife is apparent only by a slight mottling of the microstructure when the alloy is aged to optimum magnetic properties. With higher aging temperatures, however, the particles can be grown to resolvable sizes as in Figure 6*B*. Here the precipitate appears as a geometric pattern of needles which are actually cross sections through plates. This is the so-called Widmanstätten pattern which is characteristic of many reactions in the solid state. The plates are oriented with their lateral dimensions parallel to cube matrix planes, the planes upon which coherency exists at the transition state.

The microstructure of Cunico in the heat-treated and aged condition is shown by Figure 7*A*. The precipitate again is too small to be resolved; however, by a suitable heat treatment it, too, can be grown to a resolvable particle size. In Figure 7*B*, the general precipitate that produces the mottling in the grains is accompanied by lamellar nodules at the grain boundaries in which large particles of the new phases appear. Since the nodules appear and grow after the general precipitate has appeared, this is a subsequent reaction to precipitation; it promotes softening and thus is to be avoided in order to obtain optimum properties.

The change in magnetic properties of Cunico during isothermal precipitation is shown by Figure 8. The coercive force increases from a relatively low value for the as-quenched supersaturated alloy to a maximum as the precipitate is being formed in the coherent, strained condition and then it decreases as the particles break away from the matrix to assume their normal cubic structure. On the other hand, the peak induction and residual induction depend only slightly upon strain and structure and are more strongly dependent on composition and amount of the ferromagnetic phase. Changes in these account for the gradual lowering of the induction values during precipita-

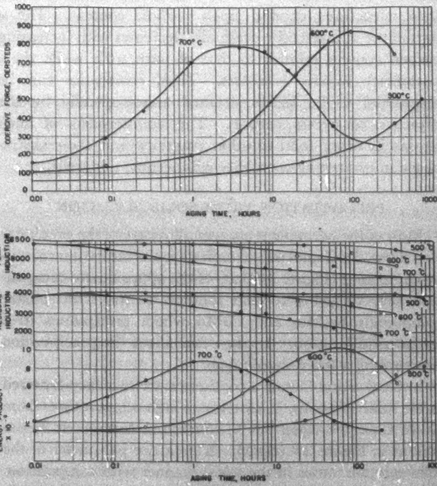

Figure 8. Changes in magnetic properties of Cunico during precipitation[3]

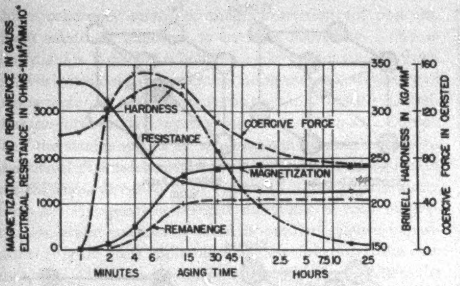

Figure 9. Aging curves for 70 per cent Au–30 per cent Ni alloy aged at 500 degrees centigrade[4]

tion. The energy product curves reflect the changes in both H_c and B_r.

The changes in magnetic properties during aging are compared with other properties in Figure 9 which refers to a Ni-Au alloy that is structurally analogous to Cunico. Since the as-quenched alloy is nonferromagnetic, the magnetization at saturation and remanence increase as the ferromagnetic Ni-rich precipitate is formed. The electrical resistance is likewise dependent principally upon composition and it decreases gradually as the matrix becomes impoverished in solute which is consumed in forming the precipitate. The hardness and coercive force again depend upon the transient state of strain in the ferromagnetic precipitate and they go through a maximum as in the case of Cunico. The effect of alloy composition on the maximum properties developed during precipitation in Ni-Au alloys shown by Figure 10 illustrates principles which have been found applicable to Cu-Ni-Co, Cu-Ni-Fe and Fe-Ni-Al alloys also. The increasing remanence with Ni content is easily understood since the relative quantity of the ferromagnetic Ni-rich phase in the two phase mixture increases with Ni content. The behavior of the coercive force depends directly upon the amount of strain in the coherent structure of the precipitate. On lowering the nickel content, the unit cell dimension of the parent matrix departs more and more from that of the nickel-rich phase; that is, the disregistry of the parent matrix and the ferromagnetic phase increases as in the upper portion of Figure 10 and greater strain is required to hold the precipitate in the coherent condition in the early stages of precipitation parallel with the greater coercivity. Here then is a direct and quantitative correlation of coercivity with strain now that the type of strain which is important has been identified.

The precipitation reaction in the Alnicos is based upon a miscibility gap in the Fe-Ni-Al alloy system. The decomposition products are body-centered cubic solid solutions, one rich in α-Fe and one rich in NiAl. Additions of Cu, Co, and Ti apparently go into solid solution in both phases. In Alnico 5 the disregistry between phases is only 0.1 per cent but in Alnico 12 it is 1.6 per cent, sufficient to permit identification of the tetragonal transition structures. The greater strains entailed by the introduction of Ti probably explain the higher coercivity of Alnico 12.

The micrographs in Figure 11 illustrate that again the submicroscopic precipitate in the normally heat-treated alloy can be grown to a prominent Widmanstätten pattern by aging at high temperatures. The large particles that grow from grain boundaries in Figure 11*A* are undesirable for the development of maximum properties similar to the nodular reaction in Cunico.

Fewer details are known concerning the reactions in other materials which can, however, be classed as the precipitation type. In the alloy Silmanal ferromagnetism is developed by the Mn atoms assuming a regular arrangement in an intermetallic compound similar to the Heusler alloys. Coercivity, however, results from the precipitation of this compound in the silver-rich matrix. After the usual treat-

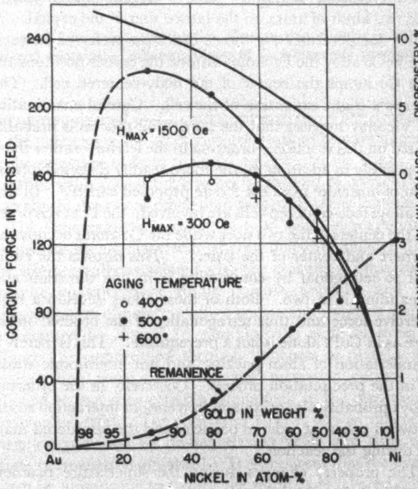

Figure 10. Properties of Ni-Au alloys aged to maximum coercive force[4]

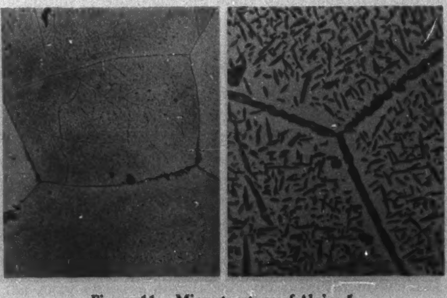

Figure 11. Microstructure of Alnico 5

A—Normal treatment: solution heat-treated, cooled in magnetic field, and aged. Magnification: 250X

B—Slowly cooled from 1,250 degrees centigrade. Magnification: 250X ments the precipitate appears as a fine dispersion of particles too small to be resolved in shape as in Figure 12*A* but aging at high temperatures provides resolvable particles as in Figure 12*B*. Vectolite is a member of the cube ferrite family—those solid solutions of the general formula MFe_2O_4 (where M is a bivalent metal ion) which have the spinel cubic structure. Many of these have interesting soft magnetic properties and thus they must be stable solid solutions. On the other hand, it has been found that the permanent magnet properties of Vectolite are due to a precipitation reaction.

SUPERLATTICE FORMATION

The third type of reaction in solid solutions is illustrated by Figure 13. At high temperatures alloys such as Fe-Co, Co-Pt, Ni-Mn, and Fe-Pt have a random distribution of the two kinds of atom on the lattice sites of the crystal. At lower temperatures the atoms order on preferred sites; in the FeCo alloy the Fe atoms assume the corner positions and the Co atoms the center of the body-centered cell. This causes a slight expansion of the cell. Careful examination of Vicalloy suggests that the hardening process is probably based on this reaction—ordering in the ferrite—rather than, or possibly in addition to, the more readily detected formation of austenite from the ferrite proposed earlier.[7] In Co-Pt alloys face-centered cells are involved; the Pt atoms order on the centers of the two sides while the Co atoms occupy the corners and center of the base. This distorts the cubic cell to tetragonal by contracting it in one direction and expanding it in two. Both of these alloys develop a high coercive force and thus tetragonality of the ordered structure as in CoPt alone is not a prerequisite. This is merely a manifestation of atom packing and not interatomic strain as in the precipitation process. Coercivity in the ordering alloys probably also originates in transient interaction strain between coherent ordered particles and the disordered matrix during the reaction.

The property changes during the superlattice reaction can be rationalized between those caused by transient strains and those characteristic of the regular atomic arrangement in the fully ordered state. The former naturally are time dependent, a factor that has not received due recognition. The latter is responsible for the development of ferromagnetism in the Heusler alloys; it also produces an increased saturation value for Ni_3Mn alloys annealed to complete order. Ordering as such decreases the electrical resistance of the superlattice type alloys in general as in Figure 14. Here ordering for one-half hour increases with increasing aging temperature. The "end state" corresponds to 24 hours at 750 degrees centigrade and the additional changes with time show that one-half hour is not sufficient to produce complete order, even at this high temperature.

Figure 12. Microstructure of Silmanal

A—Normal treatment: solution heat-treated, cold worked, and aged. Magnification: 500X
B—Slowly cooled from 800 degrees centigrade. Magnification: 1,000X

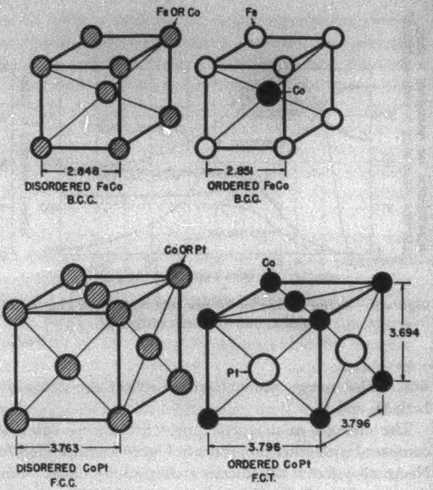

Figure 13. Crystal structure of phases involved in superlattice formation in Fe-Co and Co-Pt alloys

In contrast with Ni_3Mn, the degree of ferromagnetism of CoPt decreases as the atoms assume preferred sites in the crystal lattice. This is shown by the decreasing saturation induction and remanence. The initial increase in remanence is probably due to the relief of quenching strains. High coercivity, however, is not a characteristic of the fully ordered state but it, like hardness, goes through a maximum as ordering progresses isothermally suggesting that transient strains are the major contributor as in the precipitation reaction.

ORIGIN OF PERMANENT MAGNETISM

The new concepts relating coercive force to the formation of a new phase as a homogeneously, but anisotropically strained coherent structure during reactions in solid solutions now permits a physical interpretation of permanent magnetism and some of the little understood related phenomena. The basis of this interpretation is simply that the coherency strains resist magnetostriction thus producing a resistance to magnetizing and demagnetizing. Increasing either coherency strain or magnetostriction (of opposite signs) would be expected to increase coercivity. This is illustrated in Figure 15 where plate-like particles in the three basic orientations are considered using the domain theory of magnetism. If the coherent transition structure is such that the cubic cell is compressed in one direction as in Cunico then the strains would be those caused by tensile stress in the lateral dimensions of the plate and compressive stress in the thickness direction as in Figure 15. The lateral directions are energetically favored directions of easy magnetization when magnetostriction is positive (causes expansions) (Figure 15*A*) while the thickness direction is the easy direction if the magnetostriction is negative. When the alloy with coherent precipitate particles is magnetized (Figure 15*B*) the domains are all aligned in the classical manner. On removal of the field (Figure 15*C*) the domains in the particles of the one orientation return to their random orientation normal to the compressive stress. The domains in the particles of the other two orientations remain aligned in the direction of both the field and one tensile stress. A negative field, the coercive force, is required to reorient the domains in directions other than that of this tensile stress.

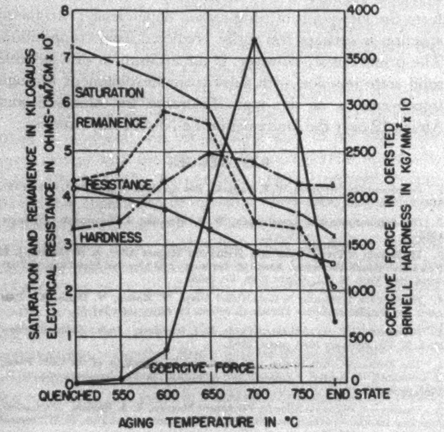

Figure 14. Properties of 50:50 atomic per cent Co-Pt alloy quenched from 1,000 degrees centigrade and aged one-half hour at designated temperature[1]

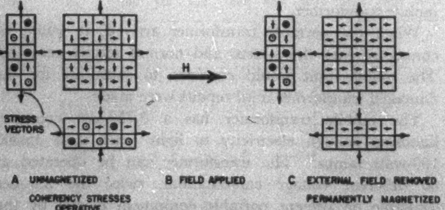

Figure 15. Domain interpretation of source of permanent magnetism; coherent plates of ferromagnetic phase in three orientations in matrix crystal, and planar tensile stresses and positive magnetostriction

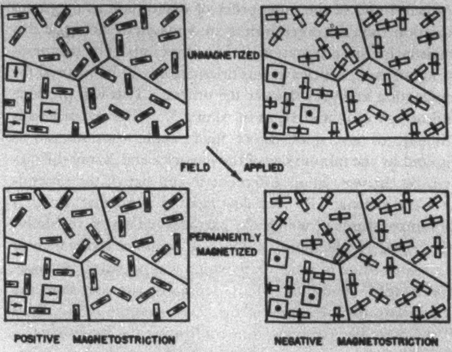

Figure 16. Domain interpretation of magnetism in polycrystalline material containing coherent plates of ferromagnetic precipitate

The ferromagnetic product of solid solution reactions is frequently highly dispersed; the particles are smaller than the size normally associated with the domain. Thus, these can be considered as single domain particles and the magnetization of polycrystalline permanent magnets can be represented by Figure 16 assuming the state of stress in Figure 15 (compression through thickness of plate). On magnetizing these materials, the magnetic vectors are aligned so that they retain a component in the direction of the applied field. The coherency stresses oppose magnetostriction provided by demagnetizing fields and thus promote permanent magnetism. It is apparent that the strains must be anisotropic to reduce the number of favored directions from three and they must be homogeneous. With heterogeneous strains such as produced by cold working, the effect would tend to balance out. In addition the elastic strains of coherency are many times those that can be produced by applying an external force.

MAGNETIC ANISOTROPY

The foregoing theory of permanent magnetism permits an explanation of the effects of cooling materials such as Alnico 5, Alnico 6, and Vectolite in a magnetic field. In Figure 15, it was shown that particles in only two of the three possible orientations contributed to permanent magnetism. In Figure 16 only a very small component of magnetization persists in the direction of the applied field for some of the particles. If these one or two ineffective orientations of particles could be avoided at the same time enhancing the more effective orientations, the observed higher magnetic properties would be expected. This can be done by the preferential nucleation and growth of particles in the desired orientation if the Curie temperature is above the temperature of aging. When disregistry is small as in

Alnico 5 and of the same order of magnitude as magnetostriction then on precipitating in a magnetic field the disregistry for one orientation will be offset in part by magnetostriction and particles in this orientation will be favored for nucleation and growth over the others. This will produce anisotropy of B_r and H_c as in Alnico 5. The hypothesis is difficult to test since direct microscopic examination is limited by the minute size of the particles and X-ray diffraction by the very small difference in cell size of the precipitate and matrix. By very slow heating of normal Alnico 5 to temperatures at which the particles will grow to resolvable sizes, it was found possible to retain a semblance of the distribution of precipitate which was present in the normally aged condition. This definitely showed that the precipitate preferred one of the three possible orientations of the plate-like particles, thus confirming the hypothesis.

Cold working prior to aging is another method of inducing magnetic anisotropy; it is commercially used for Cunife, Silmanal, and Vicalloy. The cold working of polycrystalline metals induces a preferred orientation of the crystal grains; and since the products of solid solution reactions bear discrete orientation relationships to the matrix, they will also have a preferred orientation with better properties in one direction. Limited evidence suggests that cold working might also promote growth of precipitate plates in one orientation in preference to the others as in cooling in a magnetic field. In addition, cold working accelerates reactions in solid solutions. In Vicalloy the transformation from nonmagnetic austenite to ferrite is facilitated. In Cunife and Silmanal the acceleration of precipitation permits the use of lower aging temperatures with the generally higher properties attainable at lower temperatures.

While considerations of coherency strain have qualitatively explained the dependence of coercive force on alloy constitution and structure, other factors must be considered in arriving at more quantitative relations. Perhaps particle size alone may play an important part but the existence of such an effect on coercive force has not yet been conclusively demonstrated for a pure phase in the absence of a coherent overgrowth of oxide film. The role of magnetostriction which was briefly mentioned is important since it is necessary in order for the strains to be effective. Coercive force would be expected to increase in direct proportion to both coherency strain and magnetostriction when they are in opposite directions.

Becker has proposed a relationship between these quantities as follows:

$$H_{cmax}=\frac{3}{2}\frac{\lambda_s\sigma}{J_s}$$

where λ_s is the saturation magnetostriction, σ is homogeneous stress, and J_s is the saturation induction. Here another factor is introduced; the coercive force is inversely proportional to saturation induction. The low values of this property for materials such as Vectolite and Silmanal probably contribute to their high coercive forces. On this basis, comparable values of coercive force would not be expected for comparable values of strain alone but the two other properties must be considered also. The article has discussed the aspects of strain and degree of ferromagnetism from the viewpoint of composition dependency; magnetostriction is perhaps less easily predicted from composition. The prime factor, however, is the attainment of a suitable solid state reaction with subsequent development through improvements of the type illustrated by Alnico 5 and Alnico 12 over the fundamental Fe-Ni-Al compositions.

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Mobile 3,750-Kva Transformer

A giant mobile transformer which can be rushed to the scene of a transformer failure on a power system, thus making it possible to restore electric service within ten minutes after arrival, has been completed by the General Electric Company.

The 22-ton portable transformer, which was built for the Central Vermont Public Service Corporation, is mounted in a semi-trailer and will be moved by a tractor-type truck. Normal speed for the unit is 40 miles per hour.

In operation, the huge mobile unit would be dispatched to any remote location on the Vermont power system, where lightning or any other accident has caused a sudden transformer failure.

While the tractor-trailer is enroute, a repair crew at the scene of the damage would disconnect power lines to the disabled transformer, preparatory to the arrival of the mobile transformer.

When the portable transformer arrived, it would be connected into the system and normal service resumed. The mobile unit would continue to substitute for the damaged transformer until repairs were made.

The mobile transformer has a 3,750-kva capacity, handling enough electricity to light more than 35,000 100-watt lamps. The transformer can be operated at 60 different voltage combinations, twice the number available on present portable equipment owned by the power company.

The mobile unit also will be used to keep the system in full operation whenever routine transformer maintenance and repair is necessary.

Standardization of Reactor Ratings

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THE STANDARDIZATION of reactor ratings will allow the physical properties and electrical characteristics of reactors to be standardized into classes of preferred ratings. Industry-wide acceptance of the preferred ratings should eventually result in reduced costs, shorter delivery time, and better use of materials as tests and service on the same size of reactor will point to improvements. The use of large steps between preferred ratings will hasten the realization of these benefits.

The voltage rating of a current-limiting reactor establishes the insulation strength for voltage stress. It is recommended that the latest issue of the Report of the Joint Committee of the Edison Electric Institute–National Electrical Manufacturers' Association, "Preferred Voltage Ratings for A-C Systems and Equipment" establish the nominal system voltages for reactors.

It is recommended that the continuous current ratings of current-limiting reactors be established by the preferred series of numbers; the 60 per cent and 25 per cent steps agree closely with too-infrequently used present standards, ASA C57.16-1948, Part-16.007. Other current ratings should be considered as specials; however, it is recommended that the specials be placed in preferred sizes as 12 per cent and 6 per cent steps. The short-time current rating of current-limiting reactors is well established by ASA C57.16-1948. The rating of current-limiting reactors could be matched with the continuous and short-time rating of circuit breakers for the minimum cost of this natural combination. Further study will be made on this.

Table I. Rating Target for Current-Limiting Reactors—Class: 14,400 Volts, 60 Cycles, 3 Phase, 0.10 to 10.0 Ohms

Ohms at 60 Cycles Per Cent Steps 60	25	Amperes 100	160	250	400	630	1000	1600	2500	4000
0.100	0.100								X	X
	0.125								X	X
0.160	0.160							X	X	X
	0.200							X	X	X
0.250	0.250						X	X	X	
	0.315						X	X	X	
0.400	0.400					X	X	X		
	0.500					X	X	X		
0.630	0.630				X	X	X			
	0.800				X	X	X			
1.00	1.00			X	X	X				
	1.25			X	X	X				
1.60	1.60		X	X	X					
	2.00		X	X	X					
2.50	2.50	X	X	X						
	3.15	X	X	X						
4.00	4.00	X	X							
	5.00	X	X							
6.30	6.30	X								
	8.00	X								
10.0	10.0									

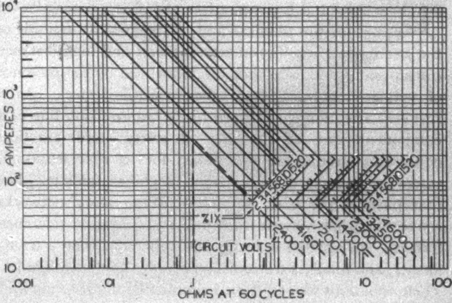

Figure 1. Reactor ratings

Ohms and amperes by preferred sizes

It is recommended that the inductance of a current-limiting reactor be expressed in ohms at 60 cycles since probably 95 per cent of the applications are at that frequency. If the reactor is rated in per cent IX, there is injected another variable, circuit volts, which frequently varies from the standard class and greatly reduces the chances of duplicating reactors. The relation between per cent IX and ohms at 60 cycles is given in Figure 1 which shows the relation

$$\text{Ohms} = \frac{\text{Per cent } IX}{100} \times \frac{\text{Circuit volts}}{\text{Amperes } \sqrt{3}}$$

The kilovolt-amperes per phase is equal to $I^2X/1{,}000$.

It is recommended that the steps in reactor inductance in ohms at 60 cycles be standardized in the 60 per cent and 25 per cent steps of the preferred series of numbers. Other inductance ratings should be considered as specials; however, it is recommended that the specials be placed in preferred sizes as 12 per cent and 6 per cent steps. Figure 1 shows the logical arrangement of ohms at 60 cycles and amperes by the recommended rating steps.

To show the ease with which current-limiting reactors with standard ratings could be applied and ordered, a typical rating target is shown in Table I. The minimum enclosure space required and other data could be tabulated. The X's cover the practical range of per cent IX of 3 to 10. This rating target shows that, in comparison with an infinite number of special rated (or tailor-made) reactors, with preferred sizes the ratings become reasonable in number.

After the ratings of reactors have been standardized, the physical sizes can be standardized. The definite trend toward the use of enclosures would allow a recommended practice to be set up between enclosure sizes and reactor sizes. The harmonizing of reactor enclosure sizes with the sizes of other metalclad equipment would then be possible.

Digest of paper 49-190, "Standardization of Reactor Ratings," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68 ,1949.

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Stationary Networks Viewed From Rotating References

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THIS ARTICLE summarizes the first of a series of studies on the physical and mathematical analysis of the steady-state stability of conventional and long-distance transmission systems as they are influenced by the presence of voltage regulators and other control devices. As a first step attention is restricted to the transmission line as a component part of the over-all system and practical equivalent circuits are established for its representation, when the connected synchronous machines oscillate. For that purpose the basic equations of stationary networks are set up when viewed from uniformly rotating reference frames. An isolated inductor and capacitor, then a transformer, and finally a transmission line are used as examples. Their equations viewed from a simultaneously rotating and oscillating reference frame are given in reference 1.

In the usual study of stationary networks it is always tacitly assumed that the observer who measures the instantaneous currents and voltages, is himself stationary in space with respect to the network under observation. The most familiar exception to that rule occurs in the analysis of a transmission system, where the observer (the d and q reference frame) is assumed to rotate with the salient pole of the synchronous generator to which the transmission line is connected. In steady-state studies the presence of a rotating observer is lost sight of because of the introduction of positive and negative sequence equivalent circuits of a transmission line that are identical with the line-to-neutral single-phase representation of the actual line. This identity is preserved when they are connected to the sequence networks of the generator.

In the study of small oscillations the positive and negative sequence equivalent circuits of the transmission line differ from each other and neither is identical with the actual line when they are connected to the equivalent circuit of the synchronous machine. The presence of the rotating observer becomes now a disturbing factor. The situation is complicated by the fact that the observer connected to the salient-pole not only rotates uniformly but it takes part in the small oscillations. In consequence additional generators appear in each mesh of the sequence transmission lines, making the two types of networks still more dissimilar.

Though the analysis of such a system is rather involved it has actually been performed by Carter, Concordia, and Crary[2,3] for a resistance-inductance-capacitance network connected to a synchronous machine. These authors at first established the equation of the whole system along a stationary a, b, c reference frame, then transformed the resulting equations to a simultaneously rotating and oscillating reference frame d, q, o. Their reasoning runs parallel with that of Park[4] in establishing the equations of a synchronous machine connected to an infinite bus.

In order to develop the equations of hunting of a synchronous machine connected not to a single-mesh network but to a multimesh one such as a transmission line, the foregoing method of attack seems out of question. It would lead to a hopelessly complicated derivation. In a previous publication[1] a new point of view has been adopted by the writer in which the equations of the transmission line and the generator were established separately as viewed from a simultaneously rotating and oscillating reference frame, afterward combined. Since the equations of the synchronous machine had already been known from previous studies, it was sufficient to develop the equations of only a transmission line. Even in this case the equations of the isolated systems were so complicated that the combined system could be represented only by means of an equivalent circuit.

The new method of attack had two disadvantages. Because of the oscillations of the reference frame each mesh of the transmission line contained an extra generator, and no simple physical picture could be established to represent the positive and negative damping and synchronizing torques contributed by various portions of the transmission system.

By trial and error the writer has discovered that both of these limitations are removed if the stator reference frame is assumed to rotate uniformly, without taking part in the small oscillations of the rotor. The reference frame on the rotor continues, however, to take part in the oscillations.

The present study undertakes to develop the transient, steady-state, and small oscillation equations of resistors, inductors and capacitors when arranged in a balanced 2-phase network and viewed from a set of uniformly rotating reference frames. At first the equations are established along the physical d and q frame showing that for each 2-phase mesh the equations are analogous to those of a 2-phase rotating machine containing magnetic and dielectric fluxes. Afterward the hypothetical sequence axes, f and b are introduced and by a third transformation the desired equivalent circuits are established. These can be easily combined with the equivalent circuits of an oscillating synchronous machine whose stator reference axes also rotate uniformly.

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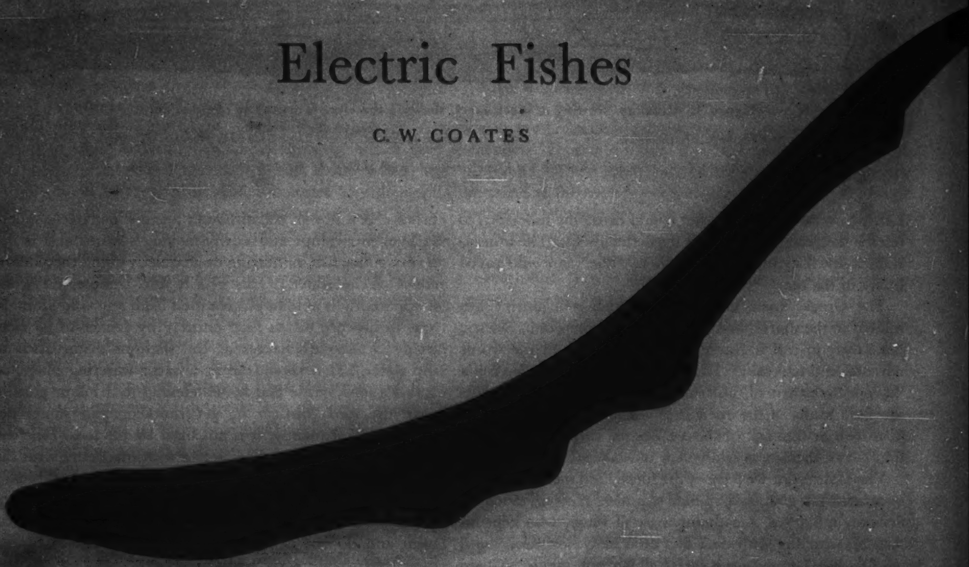
Electric Fishes

C. W. COATES



The first in a series discussing the nature of energy sources in fishes, this article by the curator of the New York Aquarium reviews the several types of fish exhibiting electrical actions. However, emphasis is placed on the so-called "electric eel," found in the fresh waters of tropical South America, which is the most potent electrically of all the electric fishes.

ALL ANIMALS in the phylogenetic scale above those which have tissues but no organs, which is to say that all animals above and including the most primitive worms, have developed some sort of mechanism that both produces and operates on electricity. In almost all animals this is a purely internal phenomenon, the nervous system, by means of which the creature sees, hears, feels, tastes, smells, moves, and thinks—if it thinks at all. In a few very special animals, there has been developed a modification of this in that some of the electricity produced can be released outside the body rather than being confined within it. All of these animals are fishes, which is not surprising, for it would not do a terrestrial animal, a bird or insect, for instance, much good to have electricity which can be released outside the body when there is no medium to conduct it. Why only some fishes have produced this peculiar mechanism, or why any of them did so, is something about which we can only conjecture, but it remains that a number of fishes, some extinct and some living at present, have developed it.

Those fishes which have developed electrical powers have not all developed them to the same extent, nor even in the same way, as far as we can now say, but no matter how it was developed, or to what extent, the end product is the same, differing only in magnitude. It is all electricity of the same sign at a given pole, chemically produced, intermittently released, and under the control of the individual concerned.

There are living at present five or six kinds of electric fishes, some in fresh water and some in sea water, and living in the temperate and tropical zones of the world.

ELECTRIC FISHES IN HISTORY

Before electricity itself was recognized, the peoples of those parts of the world in which electric fishes occur had recognized something quite peculiar about them and had tried to put some sort of explanatory label on them. One of them, the electric catfish of the Nile and other fresh waters of Africa, is pictured in the ancient hieroglyphs and was one of the fishes sacred to the Egyptians. Ancient Arabs, not recognizing anything particularly sacred about the fish, called it "numb fish." This species, and another, the torpedo, which occurs in the Mediterranean, were also called "The Protector of Fishes," on the theory that if a netful of fishes contained any of these, the electric currents

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Essentially full text of a conference paper, "Electric Fishes," presented at a Conference on Energy Sources held during the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949.

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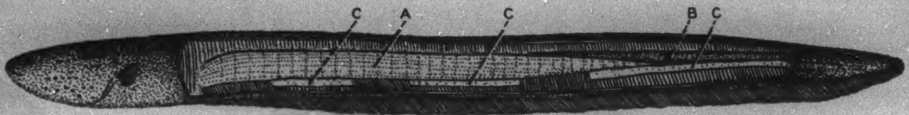

Figure 1. Cutaway drawing of electric eel, showing the electric organs on one side only

A—The large electric organ *B—The bundles of Sachs* *C—The organs of Hunter*

The head and body comprise only about the first fifth of the total length of the fish; the electric organs are all in the tail

passing up the lines of the net would cause the fishermen to release them and thus liberate the netted fishes. The translation of the Egyptian hieroglyph is, "the man who saved many in the sea."

The Greeks knew the torpedo, which is a marine fish related to the sharks, and enough of the effects of its electric discharge, to call it Narke, from which we get the words narcotic and narcosis. The Romans called the same fish a "torporific creature," able to induce torpor by means of its shocks. Many of the ancient physicians prescribed shocks from one or another of these fishes for various illnesses, so that electrotherapy is really very old indeed.

The first record we have of the torpedo in medicine is as a treatment for gout and similar troubles, recommended by Scribonius Largus, a contemporary of Pliny, who kept his patients standing with their feet on a black torpedo, "until the foot and leg up to the knee had become numb." Galen talked about such therapy as if it were more or less accepted, and many other physicians used it. As a matter of fact, in the 11th century, we have record of a Moslem doctor, Ibm-Sidah, believing that a living electric catfish, placed on the brow of a person suffering from an epileptic fit, had beneficial effects.

Some people even believed that these fishes, or parts of them, would relieve the effects of love, or perhaps we should say the ill effects of love, and used them as love charms.

Apart from this, however, the phenomenon of their electric powers had been recognized, for the physicist, Hero, at the end of the second century B.C., drew an analogy between light passing through water and the ability of the shock of an electric fish to pass through iron, brass, and other solid substances.

Much later, Volta recognized the similarity between the shocks of an electric fish and his voltaic pile, and the electric eel, which had by now been discovered in South America, had been examined by Benjamin Franklin, by Cavendish, who made an electrical counterpart, and Faraday, who was able to establish the direction of the flow and also the points of maximum voltage, and who "entertained" his friends by making them form rings, hand to hand, to take shocks from the creature. In fact, the electric eel had become so well known that in 1777 an advertisement appeared in London inviting the gouty, rheumatic, and similarly afflicted to try the effects of a shock at two shillings and sixpence a jolt.

THE ELECTRIC EEL

The electric eel of the fresh waters of tropical South America is the most potent, electrically, of all of the electric fishes. It is not an eel, although it is distinctly eel-shaped. It lives in swamps and slowly-moving streams and is not a very active fish, preferring to lie quietly along the shallow edges of the water. This gets it into trouble, for while it apparently is able to protect itself from any wild animals, and to procure all its food entirely by means of its electricity, it also discharges at the slightest disturbance in the water. If it should lie at a cattle-watering place, or across a ford, cattle and horses coming to drink or passing over the ford, disturb it, get shocked, and sometimes killed. Consequently, it is not liked by the local ranchers and cowboys who arm themselves with machettes with the handles insulated, and chop every eel they see into bits.

Contrary to the electric eel, the other electric fishes seem to use their electric organs as an auxiliary defense mechanism and do not depend upon them entirely to obtain their food.

If one watches an electric eel in a tank, it will be noticed that the fish rises occasionally to the surface of the water and gulps in some atmospheric air. This is natural, for while being a true fish, the electric eel cannot breathe under water. In fact, it may be drowned in 15 minutes or so by denying it access to the surface. It breathes, not by means of gills, nor of lungs, but by special processes in the mouth, covering the tongue and palate. This arrangement has been of inestimable advantage to us, for it enables us to keep the eel out of water for long periods of time, hours in fact, if we wet the inside of its mouth once in a while with a little water. By taking electrical measurements out of water we have many less complications than we would have if these all had to be made in water, or on a fish unable to live properly outside the water.

We do not know anything at all of the breeding habits of electric eels, and have very little second-hand information. Such as we have indicates, however, that during the rainy season the mature eels migrate into swampy areas from which they return with a group of infant eels which always swim close to the head of one parent. They do not seem to be independent until they are five or six inches long, at which length they already have 200 or 300 volts. At one inch long they have some electricity, but only enough to tickle the palm of the hand they are held in. The narcine, one of the small electric fishes of the ocean which has living young, has been caught while carrying young. In at least one case the mother fish was dead but discharges from a number of young still living inside her body could be felt outside.

From the headpiece of this article it is seen that the eel is long and slender, almost cylindrical. The long anal fin, running almost the full length of the body, is the sole means of locomotion. When the fish wishes to swim forwards, it merely starts a ripple at the beginning of the fin which, as the ripple runs backwards, pushes the fish forwards through the water. If the fish wishes to swim backwards, which it can do with great facility, it merely starts the ripple at the hind end of the fin. If it wishes to rise horizontally in the water, which it does occasionally, it starts a ripple at both ends, simultaneously, which meet in the middle. When it wishes to sink in the water, the ripple starts in the middle and progresses to either end. There are, of course, many more than one ripple at a time, but they all follow the pattern initially established unless the fish changes its mind as it progresses. This fin, together with the two small pectoral fins situated well forward so that they look somewhat like ears, both in placement and shape, are all the fins the fish has. The anal fin starts at a point close to the head end of the fish, rather than at a point well back along the body, as is the case with most fishes. This is not as different from the shape of most fishes as it appears, for the body actually ends where the fin starts. That is, the whole head and body of the fish are contained in the first 20 per cent of its total length, the rest being tail. The vent is situated at a point about midway between the snout and the end of the body. This is virtually the end of the head and the beginning of the body. The fish, having no teeth, but merely denticles in its jaws, must swallow its food whole, so that no matter what it immobilizes with its electricity, it only eats such small creatures—fishes, frogs, and such—as it can engulf.

There is a series of lateral line pits running along the tail and body. At the end of the head this lateral line breaks up into a pattern of pits which are greatly increased in size. These may be observed near the snout in the illustration. The function of the lateral line in fishes is not entirely understood, but it seems to be some sort of organ which operates between the detection of pressure waves and as a tactile organ.

SOURCE OF THE DISCHARGES

As Figure 1 indicates, there are three separate organs, *A*, *B*, and *C*. The large organ, *A*, is the main battery, so to speak. This is the business organ from which is liberated the large discharges, and is called the large electric organ. It is paired, that is, there is one identical with it on the other side of the tail of the fish. It starts immediately at the end of the body and continues to a point about two-thirds down the tail. At this place it becomes smaller and its place is taken by a second pair of organs, the bundles of Sachs, *B*, which enlarge at the expense of the large organs. The arrangement of cells is similar in both organs, but the cells of the bundles of Sachs are larger. The electric cells, which virtually fill the organs, are arranged in series-parallel in the fish, prevailingly in series. Their voltage is about 0.1. They vary in size in relation to the size of the fish. In a very small fish there may be as many as 30 per millimeter, so that we can read 28 or 30 volts per centimeter of length. As the fish grows, the cells grow longitudinally so that in a very large fish the voltage, although the same per cell, may not be more than four or five per centimeter. A larger fish can deliver more current, however. The voltage delivered by an eel differs between individuals, and ranges between 450 and 600 volts. We have had a few individuals with a little more than 600.

One reason for the cells remaining more or less constant in number, so that there is always a large voltage, becomes apparent when we consider that a small eel must have, for its protection, enough electricity to discourage potential enemies. It is a curious fact that while it is virtually impossible to find any individuals of some of the nonelectric relatives of the electric eel with intact tails, we have found only one electric eel that was mutilated, and this was damaged in such a manner as to suggest it had been cut by one of the machette-swinging cowboys mentioned previously. It was not cut soon enough, that is, close enough, to be fatal, apparently.

The discharges from the large organ are characteristic in shape and are released in trains of about ten or so and as many as 300 or 400 may be liberated per second in a fresh eel. The polarity is positive at the head end, negative at the tail end. There is no reversal. (The polarity of the marine electric fishes is from dorsal to ventral, dorsal being positive. In these fishes the organ is very wide and flat, low voltage, large current, an obvious adjustment to the different conductivity of the medium in which they are living.)

The bundles of Sachs release discharges too. These are always approximately one-tenth of the value of those from the large organs, varying individually as the large organ's discharges. They are not released in trains, however, but singly. A fish which is uneasy, or is cruising about in the water, releases discharges from this organ at the rate of 20 or 30 per second. If it becomes a little more excited, this rate may reach 50 a second. The fish may "talk matters over" by means of this discharge, and it seems as if this discharge is used as a sort of exploration device.

At a very early age, the eyes of an electric eel become clouded (cataracted) and it may be that they are damaged by their own or other eel's discharges. Also, it is quite likely to live in muddy water where eyes would not be of much good anyway. Even so, it finds its way about very

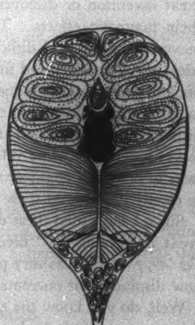

Figure 2. Cross section of electric eel, striated area showing electric tissue, dotted areas swimming muscles

The total amount of electric tissue approximates 58 per cent of total mass of the fish nicely and can always locate any disturbances of any sort. If the water is disturbed in some mechanical manner, with the fish at a distance, they can always find the site of the disturbance. They can readily find a fish or other small food animal in the water, and if one fish is induced to discharge, others can always find the head end of the discharging fish, either in darkness or light. If electrodes are put into the water and electricity discharged through them, the eels will always be attracted to them, first to the nearest electrode, regardless of polarity, and subsequently to the positive electrode, which, of course, would correspond to the head end of another eel if it were discharging.

When the fish is locating anything, or might be suspected of desiring to locate anything, the bundles of Sachs are always discharging, at an increasingly rapid rate as it becomes more excited. Since it can locate an electric discharge, can locate a living, but immobilized animal, or even such an obstacle as a wall after using its own discharges from this organ, it would seem that it has some sort of receptor organ other than eyes or ears or nose. This seems to be the case, and these receptors seem to be located in the enlarged pores of the lateral line where they are carried around the head of the fish. We have been unable to find anything of particular interest beneath these pores so far, but if they are removed or insulated, the fish does not seem able to find its way about. It would almost seem as if these are the receiving end of an electric finding apparatus, the bundles of Sachs being the transmitting end.

A single discharge of this organ usually immediately precedes a train of discharges from the large organ.

There is still another electric organ, the organs of Hunter, *C*, in the drawing. These are very slender, run the whole length of the anal fin, are located in the base of this fin, and the discharge is somewhat anomalous. It appears irregularly and seems to be a function of the discharge of the large organ.

Figure 2 shows a cross section of the tail of an electric eel about midway between snout and end of tail. At the sides and above the spinal column and the swim bladder there are five pairs of muscles. These are the standard swimming muscles. The large area beneath these muscles is the electric organ. At this point, it is almost all made up of the large electric organ. The organ of Hunter lies along the base of the anal fin, and there is a trace, not discernable, of the bundles of Sachs lying immediately above the large organ. The electric organs, besides being of considerable length in relation to the length of the fish, are also of considerable area. It is here, the parallel part of the series-parallel arrangement of the cells, that an increase occurs as the fish grows.

Electrical Essays

Electromagnetic Waves on Wires

I am always ready to improve my mind, and particularly to increase my knowledge of electricity, so when I saw that one of the engineers of the company where I work was giving a lecture on electric waves on wires, I decided to go to it, even though it was very likely that the mathematics would be over my head.

The engineer started out by praising Maxwell and his great invention or discovery of displacement currents and their magnetic effects. These displacement currents removed all the logical difficulties which had bothered electrical theory before, and furthermore they predicted a new phenomenon, electromagnetic waves in space which Hertz so brilliantly confirmed experimentally. Without these displacement currents, there would be no electromagnetic waves moving with the velocity of light, and no radio. In fact, to hear this engineer talk, there would be no nothing in electricity without these displacement currents.

Since I have used these displacement currents in my own great invention, the "Electromagnetic Space Ship" (*EE, Feb '49, p 145*), I was very pleased. I waited eagerly to hear how displacement currents made electric waves on wires.

Well, do you know the engineer wrote down some equations, and presently had waves traveling up and down the wire with the velocity of light, reflecting completely at open or short-circuited ends, so they were real honest to goodness waves, and not once in all this did the engineer mention displacement currents. Did I feel let down! After all this talk about how wonderful these displacement currents are for wave propagation, he did not even use them.

The engineer's mathematics went something like this. Take a little length of the line Δx; the voltage required to change the current in it at a certain rate, $\frac{\delta i}{\delta t}$, will be $L\frac{\delta i}{\delta t}\Delta x$ where L is the inductance of the line per unit length. This voltage is supplied by the potential difference at the ends of Δx, which naturally is $-\frac{\delta V}{\delta x}\Delta x$, so we have

$$L\frac{\delta i}{\delta t}\Delta x = -\frac{\delta V}{\delta x}\Delta x \qquad (1)$$

where with a handy eraser, we rub out the Δx's. On the other hand, the charge on the little piece of line is $CV\Delta x$ where C is the capacity per unit length of the line. The rate at which this charge increases, $C\frac{\delta V}{\delta t}\Delta x$, must be just equal to the excess of the current flowing into one end of Δx, to that flowing out the other, or $-\frac{\delta i}{\delta x}\Delta x$. We have

$$C\frac{\delta V}{\delta t}\Delta x = -\frac{\delta i}{\delta x}\Delta x \qquad (2)$$

where again an eraser will eliminate the Δx's.

With these two equations, the engineer went to town, and made the waves do all their tricks with not one peep about displacement currents or any apology to Maxwell.

Naturally I had some questions to ask after the lecture:

1. **What happened to the displacement currents which were so essential to wave propagation?**

2. I suppose $Li\Delta x$ is the flux linkages of the little piece of line Δx. How do you tell when a flux line links Δx? With Δx so short, it would certainly make a very poor key ring. (See, "Flux Linkage of an Open Circuit," *EE, Nov '49, pp 984–5*).

3. If I charge a very short piece of line Δx, the lines of electric force run out ahead and behind, so that the capacity is not proportional to Δx as is assumed in equation 2, isn't that right?

4. If I draw the equipotential surfaces for a charged particular short piece of line Δx_1, then some other short piece of line Δx_2 will lie on one of these equipotential surfaces and will have a potential not zero, even though it has zero charge. The voltage on a piece Δx, then, will depend not only on the charge on it but on the charges on the other Δx's, so that $CV\Delta x$ will not be the charge on Δx as is assumed in equation 2. In other words, there will be mutual capacitance coefficients between the Δx's which are completely ignored in equation 2, isn't that right?

5. In the same way, aren't there mutual inductances between the Δx's which are completely ignored in equation 2?

6. In the figures used to illustrate the talk, the lines of electric force go straight out perpendicular to the line. If the lines of electric force really did do that, that would settle my questions 3, 4, and 5, I suppose, but wouldn't that make the transmission line be an equipotential surface? And how could $\frac{\partial V}{\partial x}$ be other than zero on an equipotential surface?

I was going on to my seventh question, when the engineer said that his wife gets mad when he gets home late for dinner so that he'd better get going home, so I didn't get all my questions asked, let alone answered.

J. Slepian, Alter Ego

Can you answer these questions for Alter Ego?

The author found a total of 26 books classified under "Electrical Engineering" on the shelves of the library at the Westinghouse Research Laboratories, which gave some treatment of waves on transmission lines, and at least presented the transmission line equations 1 and 2. Of these, only two, one a German book, and the other an American, gave a satisfactory treatment which would withstand the criticism of Alter Ego's questions. Of the remaining books, only two mentioned displacement currents at all, and these only in later chapters than the one treating waves on wires.

Should they not all at least indicate how, or at least mention that, for waves traveling with the velocity of light, c (the ratio of the absolute electromagnetic unit of charge to the electrostatic unit), the displacement currents take care of Alter Ego's questions 1, 2, 3, 4, and 5?

J. SLEPIAN (F '27)
(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

A Transformer

The engineer from the land of pure electrical constants requests the author to submit a box of his design to the readers of *Electrical Engineering* for analysis. Remembering the engineer's trickery on a previous occasion ("Two Boxes," *Sep '49, pp 763–4*), the author questions him at length about his device which has all the appearances of an ordinary power transformer. The following description is given by the engineer:

1. The device is not a true transformer but performs like one at 60 cycles.
2. The ratio of transformation is two to one.
3. The transformer takes no exciting current.
4. The series impedance of the transformer is zero and its secondary terminals should not be short-circuited.
5. All elements of the design have finite values and relatively low ones at that.
6. There are no losses whatever in this so-called 60-cycle transformer.
7. The high side is not insulated from the low side but when tested with 60-cycle voltage from a terminal of the high side to a terminal of the low side, the transformer shows infinite impedance.
8. The usual polarity test can be made but the results will be startling. Indications will be of subtractive polarity, ratio will not hold, and current will be drawn from the line.

The author now asks the reader: Are there enough clues in the foregoing description to permit reproduction of the engineer's transformer?

A. A. KRONEBERG (F '48)
(Southern California Edison Company, Los Angeles, Calif.)

Answer to Previous Essay

Lissajous Figure. The following is the author's answer to a previously published essay (*EE, Dec '49, p 1081*).

The figure appearing on the screen of the cathode-ray oscillograph is an outline of the AIEE emblem (Figure 1).

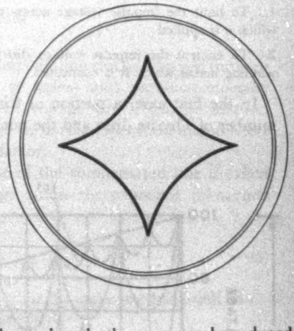

Figure 1. AIEE emblem

The equations of voltage given in the essay can be reduced by trigonometric substitution to:

$$e_1 = 100 \sin^3 wt \qquad (1)$$

$$e_2 = 100 \cos^3 wt \qquad (2)$$

and then combined into one equation eliminating time "t"

$$e_1^{2/3} + e_2^{2/3} = 100^{2/3} \qquad (3)$$

This is the equation of the hypocycloid of four cusps or the curve described by a point on a circle of 25 unit radius which rolls along the inside of a fixed circle of 100 unit radius.

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A. A. KRONEBERG (F '48)
(Southern California Edison Company; Los Angeles, Calif.)

Use of Thyrite in Power Transformers

J. R. MEADOR
MEMBER AIEE

ELECTROSTATIC SHIELDING has long been recognized as an effective means of controlling the impulse voltage distribution in transformer windings. Under certain conditions the same, or a better, result can be achieved by the use of Thyrite.* Developed as a material for lightning arresters, Thyrite is characterized by its nonlinear resistance; it passes a current proportional to a relatively high exponent of the applied voltage. Thyrite is a ceramic-bonded inorganic resistance material manufactured in the form of disks.

In recent years there has been a great increase in the use of autotransformers, load-ratio control transformers, and transformers with complicated winding arrangements and wide tap ranges. The transformer designer has, thus, been faced with new problems of winding protection against overvoltages. Thyrite, immersed in the transformer oil and shunting portions of the windings, has, in the past ten years, achieved a prominent position in the solution of these problems.

The two principal uses of Thyrite within transformers are

1. To limit the impulse voltage across the portion of winding to which it is applied.
2. To control the impulse voltage distribution in the portion of winding across which it is connected.

In the first case, a portion of winding is shunted by a number of Thyrite disks and the nonlinear character of the material is such that at normal power-frequency operating voltages, its resistance is sufficiently high so as to have no measurable effect on the transformer. When carrying high surge currents, however, its resistance falls and limits the voltage drop across it and across the connected portion of the winding to a predetermined, safe level.

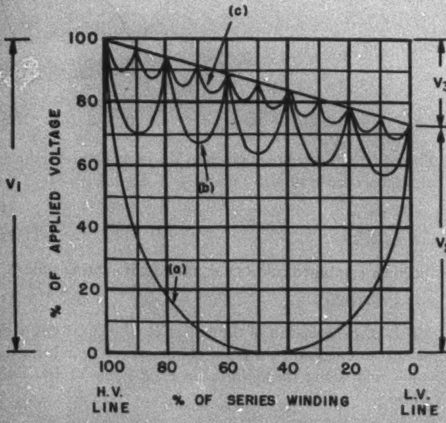

Figure 1. Effect of number of interconnections on initial impulse-voltage distribution in Thyrite-shielded series winding

Curve A—no interconnections
Curve B—four interconnections
Curve C—nine interconnections

In some instances, additional protection is needed, and the Thyrite is called upon to serve its second function. Under impulse conditions the voltage distribution in a winding is determined by its capacitance and inductance network. By shunting the winding with Thyrite and connecting intermediate points of the winding to intermediate points of the Thyrite stack, the impulse voltage distribution in the winding can be made to approach its normal power-frequency linearity.

Typical Thyrite applications are in transformers having abnormally large tap ranges or where, due to some unusual design requirement, the impulse voltage distribution in the tap winding is difficult to calculate with a sufficient degree of accuracy.

Thyrite is particularly useful in autotransformers where, for example, the major part of a series winding may be tapped out, or where, to have greater flexibility, it is desirable to locate taps directly at the line end of a winding. The series windings of regulating transformers are normally shunted by Thyrite.

When a portion of winding is shunted by Thyrite, three thermal requirements are met. They are

1. The number of disks in series is such that with continuous operating voltage across the Thyrite a temperature of 95 degrees centigrade is not exceeded.
2. The Thyrite loss during induced voltage test (usually 3.46 times normal voltage or less) is within the heat storage capacity of the disks.
3. The energy input into the Thyrite is within its heat storage capacity during a system fault, when abnormal voltages may appear across a winding (notably the series winding of an autotransformer).

All of these requirements are subject to calculation and are the basis for the selection of the Thyrite.

The use of Thyrite for controlling transient overvoltages within transformers does not eliminate the necessity for normal lightning arrester protection from line to ground. external to the transformer.

Thousands of Thyrite disks a year are used in power transformers in the manner described. None has failed to function properly in the hundreds of transformers to which they have been applied during the past ten years.

Digest of paper 49-192, "Use of Thyrite in Power Transformers," recommended by the AIEE Committee on Transformers and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

J. R. Meador is with the General Electric Company, Pittsfield, Mass.

* Thyrite is a registered trade-mark of the General Electric Company.

Series Capacitor and Double Conductors in the Swedish Transmission System

ÅKE RUSCK BO G. RATHSMAN

In Sweden the water power resources are located in the northern provinces, while the consumption is concentrated in the southern parts. Because of the large transmission distances the stability of existing 220-kv and the future 380-kv systems is the principal limitation for loading the lines.

AS THE WATER power resources in Sweden are located in the northern provinces, while the consumption is concentrated in the southern parts, the high-voltage network is characterized by large transmission distances. In the existing 220-kv network the average transmission distance is 300 miles and when all hydroelectric power has been developed the distance will have been increased to about 450 miles. This is the main reason why it has been found economical to introduce the higher transmission voltage of 380 kv.

Because of such great distances the transmission capacity both for the 380-kv and the 220-kv system is determined by stability conditions. For the 220-kv system the common methods of increasing the static and dynamic stability limits have already been utilized for a long time.

Efforts to increase transmitting capacity were continued during the design of the 380-kv system and promoted by the wish to avoid further extensions of the 220-kv network above the six lines already existing and planned. The investigations were concentrated on reducing the influence of the line reactance by the use of series capacitors and double conductors.

A series capacitor is being installed in the 300-mile 220-kv Stadsforsen-Hallsberg line and double conductors are introduced not only on the 380-kv line, but also on two 220-kv lines of about 200 and 60 miles respectively. Both the capacitor and these 220-kv lines will go into operation this fall. Moreover, it has been decided that the first Swedish 220-kv line, the 200-mile Krångede-Horndal line, which was constructed in 1936 and belongs to the Krångede Power Company, will be rebuilt and equipped with double conductors in the summer of 1950.

SERIES CAPACITOR INSTALLATION FOR 220 KV

The capacitor in the Stadsforsen-Hallsberg line will be installed near the midpoint of the line, which means that the short-circuit currents through the capacitor are reduced almost to the lowest possible value. Moreover, the operating conditions for the distance relay protection of the line are simplified.

Degree of Compensation and Transmitting Capacity. The size of a series capacitor can be characterized by the degree of compensation, k, which indicates the ratio between the capacitor reactance, x_c, and reactance of the line itself, x_L.

If it is assumed that the generating power and the load are increased in the same proportion as the transmitting capacity is raised by the installation of the capacitor, the load on the compensated line will go up from the original value, P megawatts, to

$$P_L=\frac{x_L}{x_L-x_c}P=\frac{1}{1-k}P \text{ megawatts} \tag{1}$$

while the load on the other lines will remain unaltered.

The increase of the total transmitting capacity of the parallel-working network will be

$$P_t=\frac{x_c}{x_L-x_c}P=\frac{k}{1-k}P \text{ megawatts} \tag{2}$$

A desired degree of compensation can be attained through different combinations of series- and parallel-connected capacitor elements. The voltage which can be allowed across the capacitor units in normal operation and at short circuits is the deciding factor.

If the maximum load of the compensated line is called P_{max}, the highest voltage across the capacitor in normal service will be

$$E_c=\frac{k}{1-k}\,\frac{x_L}{\sqrt{3}E}P_{max} \text{ kilovolts} \tag{3}$$

The corresponding power for the capacitor bank will be

$$P_{cr}=kx_L\left[\frac{P_{max}}{(1-k)E}\right]^2 \text{ megavolt-amperes reactive} \tag{4}$$

The series capacitor must be designed to withstand these stresses. From an economical point of view it is also important that the capacitor need not be enlarged because of transitory stresses.

The voltage over the capacitor at short circuits is shown in Figure 1. This shows the maximum voltage stress in proportion to E_c at short circuits on the compensated line and at short circuits behind the circuit breakers at the line terminals. In the first case the overvoltage will be from 5 E_c to 6 E_c. As it would be too costly to design the capacitors to be able to sustain these high stresses, and as it has been desired to use capacitors of standard type, the bank will be protected against overvoltages by a spark-gap. The tensions occurring at short circuits outside the compensated line will not be higher than about 2.5 E_c at the degrees of com-

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Essentially full text of a conference paper, "Series Capacitor and Double Conductors in the Swedish Transmission System," presented at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949.

Åke Rusck is President and **Bo G. Rathsman** is Chief Engineer of the Swedish State Power Board, Stockholm, Sweden.

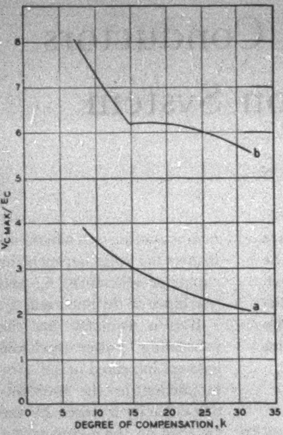

Figure 1. Maximum voltage across the series capacitor at short circuit

A—Short circuit outside the compensated line

B—Short circuit on the compensated line (maximum voltage stress occurs for $k<15$ per cent during first half-cycle, for $k>15$ per cent during second half-cycle)

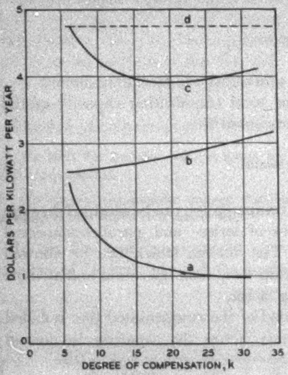

Figure 2. Annual costs of a series capacitor compensation

A—Costs of the series capacitor plant

B—Costs of increased line losses

C—Total costs (A+B)

D—Costs of a new parallel line

pensation in question. As the capacitor manufacturers allow transient excess voltages of 3 to 3.5 times the rated voltage, the spark-gap need not be adjusted for ignition under these conditions. This is an advantage as outside faults often cause a special need for the extra transmitting capacity supplied by the series capacitor.

Costs and Choice of Degree of Compensation. The degree of compensation has been determined on economic estimations (Figure 2).

A compensation of 20 per cent proves most economical and has been chosen for this capacitor plant. The corresponding nominal rating is 31.4 megavolt-amperes reactive at a rated voltage of 20.5 kv and 50 cycles. The cost of the complete installation will be about the same as the cost of 15 miles of 220-kv line.

It appears from Figure 2 that the increase in line losses makes up a considerable part of the annual cost of installation. This is true because the line, which was not originally intended for compensation, is constructed of 500,000 circular mil copper and equivalent steel-aluminum conductors. If the line had been designed to operate with the series capacitor it would have been economical to decrease the line resistance in the same degree as the reactance. The most economical degree of compensation would have increased from 20 to 30 per cent; the conductor cross section would have been reduced 15 per cent, and the transmission costs would have decreased to about 70 per cent in comparison with an economically-dimensioned noncompensated line.

Data of the Capacitors. The plant will be erected close to the line, in which a by-passing switch will be inserted (Figure 3). For disconnection from the line two switches are provided. The capacitor bank consists of 396 units in each phase. The supply of these units is equally shared between the two principal Swedish manufacturers of capacitors, Allmänna Svenska Elektriska Aktiebolaget and Sieverts Kabelverk. The units are rated 30 kilovolt-amperes reactive at 1.63 kv and 23 kilovolt-amperes reactive at 1.81 kv. They will conform to Swedish standards for shunt capacitors and also will have to withstand special tests planned to test their series operation specifications.

Parallel to the capacitor is the spark-gap and a by-pass circuit breaker. The gap will be adjusted to ignite at a crest value of 80 kv or 2.8 times the rated voltage of the capacitor. The circuit breaker will have a relay equipment assigned to close the circuit breaker after the gap has ignited and to retrip the circuit breaker after a certain interval provided the current has decreased to the normal value. The circuit breaker also is closed on impulse from an equipotential protector. Parallel to the gap is a small capacitor to prevent the gap from igniting transient surges.

Structural Features. The capacitors will be suspended in a steel structure which will be cheaper and simpler than mounting them on isolated stands. The steel structure is designed for a future extension of the plant to a 30 per cent compensation, when the total weight of the capacitor bank will be 160 tons.

A 380-KV SERIES CAPACITOR

Studies have been made of the possibilities of utilizing series capacitors economically for the 380-kv system also. The most economical degree of compensation has proved to be about 40 per cent. The capacitor should have a rated voltage of 55 kv. If the load on the line before the compensation is 375 megawatts such a series capacitor will increase the transmitting capacity by 120 megawatts. Calculations prove that series capacitors are capable of reducing the annual transmission cost per kilowatt-year of the 380-kv system by approximately 20 per cent.

DOUBLE CONDUCTORS

Characteristics of Bundle Conductors. The characteristics of a line where the single conductor has been replaced by two or several parallel-connected cables are well known. The bundle conductor thus obtained has a lower reactance and a correspondingly higher capacitance than the single conductor. Further, the permissible operating voltage with regard to corona is raised. If the number of parallel cables per phase is increased the result will be more pro-

Table I. Data on Lines Provided with Double Conductors

Voltage and Line	Length, Kilometers	Pole Material	Dimension of Conductor, Sq. Millimeters	Resistance Ohms Per Phase Per Kilometers	Reactance, Ohms Per Phase Per Kilometers	Capacitance, Microfarads Per Phase Per Kilometers	In Service
380-kv Harsprånget-Hallsberg	954	Steel	2 by 592	0.028	0.33	0.011	Jan. 1951
220-kv Ånge-Finnslätten	330	Steel and wood	2 by 328	0.050	0.31	0.015	Nov. 1949
220-kv Untra-Håsta	93	Steel and wood	2 by 328	0.050	0.31	0.015	Oct. 1949

nounced (Figure 4). However, the main profit of reduced reactance and raised corona voltage already is obtained by the use of double conductors.

These characteristics also are influenced by the mutual distance between conductors in one phase; for a double conductor in the way shown in Figure 5. The reactance will be reduced if the spacing is increased, whereas the corona voltage has a maximum value which, in this case, is obtained at a distance of 12 inches.

For a large transmission system as the Swedish 380-kv network the reduced reactance and increased corona voltage implies two great advantages: the low reactance increases the stability limits and the increased corona voltage makes possible the application of solid stranded steel-aluminum cables of moderate standard dimensions. Through the increased capacity of the line an increased reactive power is required for compensation at low line load, but, on the other hand, there is less need of capacitors at high line load. Since most of the advantages of bundle conductors already are obtained by using double conductors and since there would be considerable construction problems and extra costs by using three or more conductors per phase, the choice of double conductors is most favorable.

As a compromise between low reactance and high corona voltage the spacing between conductors has been fixed at 18 inches. At this distance the reactance is decreased by 25 per cent, corresponding to an increase of the transmitting capacity by 30 per cent.

For the long 220-kv lines a reduced line reactance is of great value also. The raising of the corona voltage is less important as a sufficient margin can be obtained by a single conductor designed to be economical regarding cost of material and line losses. Approximate calculations show that the additional transmitting capacity achieved by double conductors on 220-kv lines is obtained at a lower or at the same cost as that achieved by construction of new 220-kv lines. A detailed report on this matter is being prepared by the International Conference on Large Electric High Voltage Systems (CIGRE) Study Committee on Extra High Voltages. For the new 220-kv lines with double conductors the distance between conductors will be the same as on the 380-kv line, that is, 18 inches. The relative reduction of the reactance and the corresponding increase of the transmitting capacity consequently will be approximately the same as for the 380-kv line.

The 380- and 220-Kv Double-Conductor Lines. Particulars of those lines which will be provided with double conductors are given in Table I.

For the 380-kv line it was intended originally to use a steel-aluminum conductor of 2 by 900,000 circular mils, but after the price of aluminum had fallen, it was possible to increase the conductor size to 2 by 1,170,000 circular mils steel-aluminum without any increase of the total cost including the cost of the line losses. This gave reduced voltage with regard to corona.

For the two new 220-kv lines it proved most economical to use 2 by 650,000 circular mils steel-aluminum conductors. On the 380-kv line as well as on the two 220-kv lines the double conductors are placed on the same horizontal level.

Influence on Line Design. The use of double conductors causes heavier strains on insulators, crossarms, towers, and foundations. According to Swedish standards for overhead lines it has to be assumed that all cables are exposed simultaneously to maximum loads. No reduction factor for double conductors is allowed. The increase of mechanical loads is considerable. The corresponding increase of line costs cannot be given accurately for the 380-kv line, because no particulars for an equivalent single-conductor

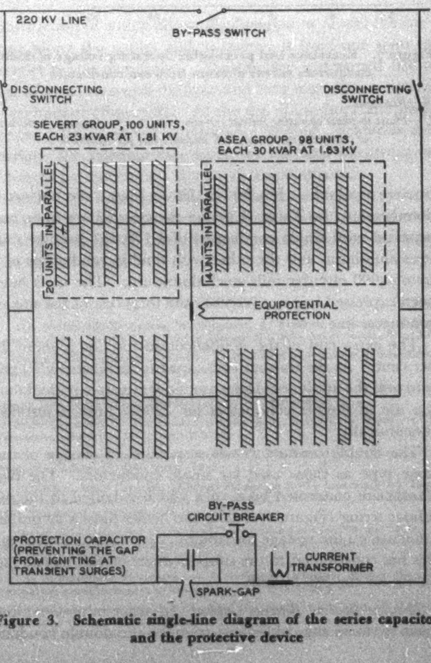

Figure 3. Schematic single-line diagram of the series capacitor and the protective device

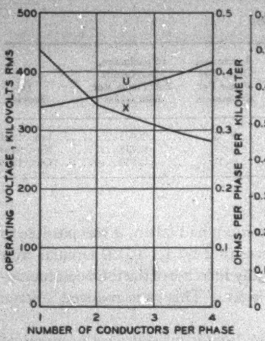

Figure 4. Reactance and permissible operating voltage on bundle conductors with 2, 3, and 4 conductors per phase and the same total cross section

X—Reactance

U—Phase-to-phase operating voltage corresponding to a maximum field intensity at conductor surface of 15.8 kilovolts rms per centimeter

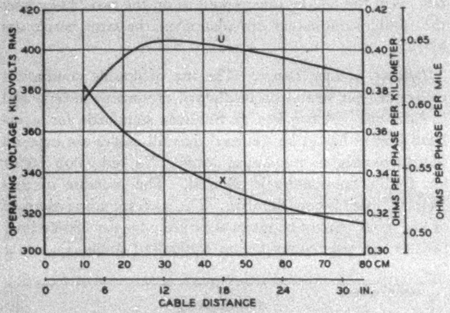

Figure 5. Reactance and permissible operating voltage of double conductors versus distance between conductors

X—Reactance

U—Phase-to-phase operating voltage corresponding to a maximum field intensity at conductor surface of 15.8 kilovolts rms per centimeter

line are available. But for the 220-kv lines a comparison is demonstrated by Table II giving the costs of two lines, one supplied with single conductors of 1,170,000 circular mils steel-aluminum and the other with double conductors of 2 by 650,000 circular mils steel-aluminum. The costs have been expressed in percentages of the total cost of the single-conductor line.

The extra cost of the double-conductor line is about 21 per cent. As the transmitting capacity increases by 30 per cent and the additional losses are moderate, it is evident that the use of double conductors for 220-kv lines is justified economically.

The double conductors are suspended in clamps of the same type as those used for single conductors. The two clamps are connected by a yoke which is bolted to the insulator string (Figure 6). The two cables have a favorable influence on the voltage distribution on the insulator string; this has contributed to the simplification of the equalizing device for the 380-kv line.

Required Spacing Between Cables. In order to prevent impacts between the cables and to make the double conductors function in the intended way the distance between the cables must be controlled.

In the 380-kv line the cables may be allowed only exceptionally to come so close together that the corona voltage falls below the limit of what is permissible as regards radio disturbances. The critical distance has been set at eight inches. For the 220-kv lines no minimum spacing is required with regard to corona phenomena but to prevent damaging of the cables impacts must not occur too often.

Table II. Comparison of Costs of Single- and Double-Conductor 220-Kv Lines

Given in Percentages of the Cost of a Single Aluminum-Steel Conductor

Conductor Area, Circular Mils	1,170,000	2 by 650,000
Poles	22.1	28.9
Conductors	25.5	29.7
Ground wires	3.7	3.7
Insulators	7.1	7.9
Suspending of cables and insulating work	4.2	4.8
Foundations	19.9	24.9
Corrosion protection	7.0	8.8
Line materials	2.5	3.3
Administration and organization of the work	8.0	9.3
Total	100.0	121.3

For the 380-kv and 220-kv lines the influence of a reduced distance between conductors on the total line reactance is relatively small, since at normal service the average spacing of all spans does not diverge appreciably from the intended value. The distance between the cables, if they are allowed to sway freely, is determined by the influence of electrical forces between the cables and by the wind.

Influence of Electrical Forces. Sideways the cables are influenced by electrical and mechanical forces, the electrical forces being the electromagnetic attraction which is proportional to the square of the current, and electrostatic repulsion which varies in proportion to the square of the voltage.

The position of the cables of the 380- and 220-kv lines has been calculated for different lengths of spans and for varying loads. Figure 7 shows the distance between the centers of the cables in the middle of a normal and a maximum span on the 380-kv line.

At no load the distance is somewhat greater than normal. At a load of 400 megavolt-amperes the electrostatic and the

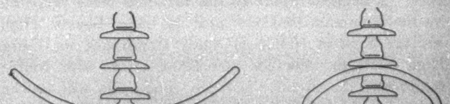

Figure 6. Lower part of a suspension insulator string with shielding ring yoke and suspension clamps

electromagnetic forces are equal, and the spacing is exactly 18 inches. With an increased load the cables approach each other and at a distance between cables of 7.5 inches the point of instability is reached and the cables clash together. This occurs in the normal span of 1,100 feet at a load of 790 megavolt-amperes.

If for some other reason the cables are brought closer together, the instable condition is reached at a lower load. This is indicated by dotted part of the curves. To separate cables which have clashed together the load has to be decreased below the value corresponding to the point of instability for cables lying against each other. At normal spans this load is 610 megavolt-amperes.

Influence of Wind. Though the influence of the electrical forces is not unimportant, especially for long spans, the main factor proves to be the wind.

The influence of wind pressure on the conductors has been studied in three test spans corresponding approximately to the maximum, average, and minimum spans of the 380-kv line. Tests have been made with the same size of cables as will be used on the 380- and 220-kv lines.

The recording of distance has been made with devices of two different types. The devices are provided with electrical contacts for 2-inch intervals of separation and each has been connected to a comptometer device. One type is intended to be modified so that it may be used on lines in service also.

The movements of the cables have been observed both with the cables swaying freely and with the distance controlled by spacers in one or several points. For the 380-kv conductors it was learned that the free span must be limited to 430 feet. For the 220-kv conductors the corresponding distance seems to be about 560 feet.

Carriage for Installing Spacers. The spacers will have to be installed after the conductors have been strung. For this purpose it has been considered most suitable to use a carriage designed to roll on the two parallel-connected cables. After comprehensive tests a carriage has been designed, the construction of which allows the lineman to propel the carriage along the cables and to convey it from one span to another by his own force. The carriage is designed like a cage of steel tubes with the front and back movable in relation to each other (Figure 8). At the top of the front and back are two pairs of wheels with braking devices. Seated in the carriage the lineman can move the carriage backways or forwards by movements similar to an oarsman's.

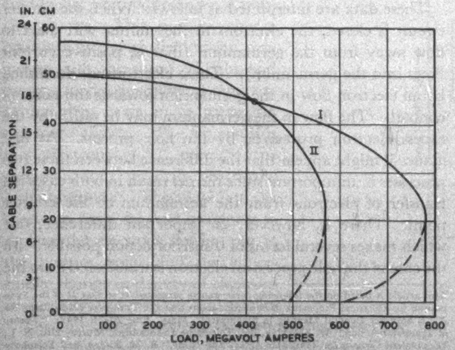

Figure 7. Distance between centers of cables as function of load

I—Normal span of 1,100 feet
II—Maximum span of 1,800 feet

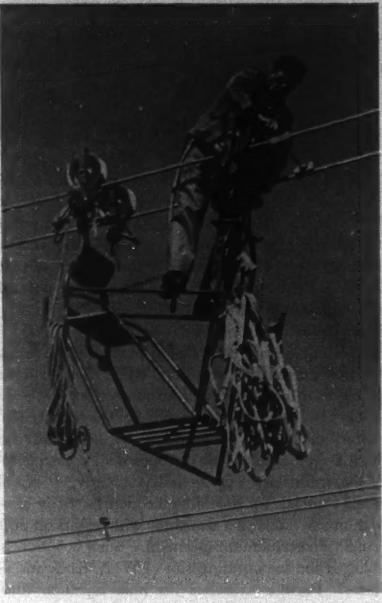

Figure 8. Carriage for installing spacers

During the installing of spacers the lineman has a ground assistant who hoists materials to him. One assistant should be able to help the three linemen, each of whom is taking care of one phase.

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Transistors

J. A. BECKER
FELLOW AIEE

As part 4 of a series of articles summarizing the material presented at the 1949 Summer General Meeting Symposium on Semiconductors and the Transistor,* this part presents recent advances in the theory of transistor action, circuit performance, and potential applications of transistors.

THE INVENTION of the transistor by J. Bardeen and W. H. Brattain[1-3] has given great stimulus to research on the interaction of holes and electrons in semiconductors. The techniques for investigating the behavior of holes in *n*-type germanium were devised in part to aid in analyzing the emitter current in transistors. The early experiments suggested that the hole flow from the emitter to the collector took place in a surface layer.[1,2] The possibility that transistors could also be produced by hole flow directly through *n*-type material was proposed in connection with the *p-n-p* transistor.[4] Quite independently, J. N. Shive[5] obtained evidence for hole flow through the body of *n*-type germanium by making a transistor with points on opposite sides of a thin germanium specimen. Such hole flow is also involved in the coaxial transistor of W. E. Kock and R. L. Wallace.[6] Further evidence for hole injection into the body of *n*-type germanium under conditions of high fields was obtained by E. J. Ryder.[7]

In keeping with these facts it is concluded that with two points close together on a plane surface, as in the type-*A* transistor,[8] holes may flow either in a surface layer or through the body of the germanium. For surface flow to be large, special surface treatments appear to be necessary; such treatments were not employed in the experiments described here and the results are consistent with the interpretation that the hole current from the emitter point flows in the interior.

The engineering aspects of the type-*A* transistor have been described in *Electrical Engineering*.[8] It consists essentially of emitter and collector point contacts on a small disk of germanium and a large area base contact. Both emitter and collector points act as rectifiers; the emitter operates in its high resistance direction. The positive holes injected into the germanium by the emitter travel toward the collector point. Here they act like a movable positively charged grid which induces an even greater electron current to be emitted from the collector point. Beside this current amplification, there is a voltage amplification because the resistance near the collector point is much greater than that near the emitter point.

HOLE INJECTION ON GERMANIUM

To understand the transistor action more completely one would like to know answers to the following questions: How rapidly do the holes and electrons drift in the germanium? What fraction of the emitter current consists of holes? How long do the holes exist before they recombine with electrons? What fraction of the current in the body of the germanium is carried by holes? How is the electron current from the collector point related to the density of holes in its vicinity? It is difficult to obtain answers to such questions in the type-*A* transistor because the points are separated by only about three mils and because the paths of electrons and holes form a complicated geometrical pattern. It has been found possible, however, to obtain answers to these questions by performing experiments in a filamentary-type transistor in which the emitter and collector are separated by distances of several millimeters and in which the holes and electrons are made to flow along a filament about one centimeter long and about 1 × 1 millimeters in cross section. These experiments are described and analyzed in detail in another article.[9]

A typical experiment which measures the time required for holes to travel along the filament is shown in Figure 1. An elongated piece of *n*-type germanium is subjected to a longitudinal electric field E applied by a battery B_1. Collector and emitter points are placed in contact, as shown, with the aid of a micromanipulator. The collector point is biased like a collector in a type-*A* transistor by the battery B_2 and the signal obtained across the load resistor R is applied to the input of an oscilloscope. At time t_1 the switch in the emitter circuit is closed so that a forward current, produced by the battery B_3, flows through the emitter point. At t_2 the switch is opened. The voltage wave at the collector, as observed on the oscilloscope, has the wave form shown in part B of the figure.

These data are interpreted as follows: When the emitter circuit is closed, the electrons in the emitter wire start to flow away from the germanium (that is, positive current flows into the germanium). These electrons are furnished by an electron flow in the germanium towards the point of contact. The flow in the germanium may be either by the excess electron process or by the hole process. At first glance it might appear that the difference between these two processes is unimportant since the net result in both cases is a transfer of electrons from the germanium to the emitter point. There is, however, an important difference, one which makes several forms of transistor action possible. In the case of the hole process an electron is transferred from the

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This article is based on the following three papers presented at section *D* of the Symposium on Electrical Properties of Semiconductors and the Transistor held during the AIEE Summer General Meeting in Swampscott, Mass., June 20–24, 1949: "Theory of Transistor Action," **W. Shockley**, Bell Telephone Laboratories, Murray Hill, N. J.; "Equivalent Circuits for Transistor Action and Noise," **R. M. Ryder**, Bell Telephone Laboratories, Murray Hill, N. J.; "The Possible Significance of Transistors in the Power Field," **J. A. Hutcheson** (M '44), Westinghouse Research Laboratories, East Pittsburgh, Pa. **J. A. Becker**, session chairman, is with the Bell Telephone Laboratories, Murray Hill, N. J.

* See *Electrical Engineering* for October (*pp 865–72*), November (*pp 937–42*), and December (*pp 1047–56*) 1949 for parts 1–3 of this series.

valence band structure to the metal. After this the hole moves deeper into the germanium. As a result the electronic structure of the germanium is modified in the neighborhood of the emitter point by the presence of the injected holes.

Under the influence of the electric field E, the injected holes drift toward the collector point with velocity $\mu_p E$, where μ_p is the mobility of a hole, and thus traverse the distance L to the collector point in a time $L/\mu_p E$. When they arrive at the collector point, they increase its reverse current and produce the signal shown at t_2.

There are two important differences between the signal produced at t and that produced at t_1. The signal at t_1, which is in a sense a pickup signal, would be produced even if no hole injection occurred. This can be illustrated by considering the case of a piece of ohmic material substituted for the germanium. Conventional circuit theory applies to such a case; however, in order to contrast this purely ohmic case with that of hole injection, a description also will be given of the conventional theory of signal transmission in terms of the motion of the carriers. According to conventional circuit theory, the addition of the current I_e would simply produce an added IR drop due to current flow in the segment of the specimen to the right of the collector. This voltage drop is denoted as $I_e R_d$ in part B, R_d representing the proper combination of resistances to take into account the way in which I_e divides in the two branches. This signal will be transmitted from the emitter to the collector with practically the speed of light—the ordinary theory of signal transmission along a conductor being applicable to it. This high speed of transmission does not, of course, imply a correspondingly high velocity of motion of the current carriers. In fact, the rapidity of signal transmission has nothing to do with the speed of the carriers and comes about as follows: If the ohmic material is an electronic conductor, then the withdrawal of a few electrons by the emitter current produces a local positive charge. This positive charge produces an electric field which progresses with the speed of light and exerts a force on adjoining electrons so that they move in to neutralize the space charge. The net result is that electrons in all parts of the specimen start to drift practically instantaneously. They flow into the specimen from the end terminals to replace the electrons flowing out at the emitter point and no appreciable change in density of electrons occurs anywhere within the specimen.

The distinction between the process just described and that occurring when holes are injected into germanium is of great importance in understanding many effects connected with transistor action. One way of summarizing the situation is as follows: In a sample having carriers of one type only, electrons for example, it is impossible to alter the density of carriers by trying to inject or extract carriers of the same type. The reason is that such changes would be accompanied by an unbalanced space charge in the sample and such an unbalance is self-annihilating and does not occur.

When holes are injected into n-type germanium, they also tend to set up a space charge. Once more this space charge is quickly neutralized by an electron flow. In this case, however, the neutralized state is not the normal thermal equilibrium state. Instead the number of current carriers present has been increased by the injected holes and by an equal number of electrons drawn in to neutralize the holes. The total number of electrons in the specimen will thus be increased, the extra electrons coming in from the metal terminals which complete the circuit with the emitter point. The presence of the holes and the neutralizing electrons near the emitter point modify the conductivity. This modification of conductivity may be so great that it can be used to measure hole densities and also to give power gain in modified forms of the transistor. This situation can be summarized as follows: In a semiconductor containing substantially only one type of current carriers, it is impossible to increase the total carrier concentration by injecting carriers of the same type; however, such increases can be produced by injecting the opposite type since the space charge of the latter can be neutralized by an increased concentration of the type normally present.

Thus we conclude that the existence of two processes of electronic conduction in semiconductors, corresponding re-

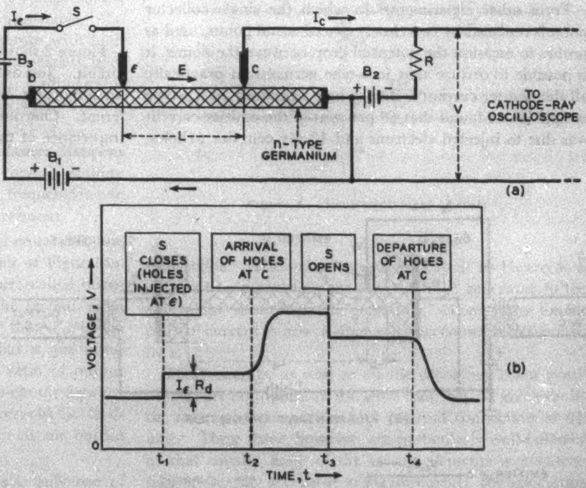


Figure 1. Experiment to investigate the behavior of holes injected into n-type germanium

A—Experimental arrangement

B—Signal on oscilloscope showing delay in hole arrival at t_2 in respect to closing S at t_1 and delay in hole departure at t_4 in respect to opening S at t_3

spectively to positive and negative mobile charges, is a major feature in several forms of transistor action.

In terms of the foregoing description, the experiment of Figure 1 is readily interpreted. The instantaneous rise at t_1 is simply the ohmic contribution due to the changing total currents in the right branch when the emitter current starts to flow. After this, there is a time lag until the holes injected into the germanium drift down the specimen and arrive at the collector. When the current is turned off at t_3, a similar sequence of events occurs.

The measured values of the time lag of $t_1 - t_2$, the field E, and the distance L can be used to determine the mobility of the holes. The fact that holes, rather than electrons, are involved is at once evident from the polarity of the effect; the disturbance produced by the emitter point flows in the direction of E, as if it were due to positive charges; if the electric field is reversed, the signal produced at t_2 is entirely lacking. The values obtained by this means are found to be in good agreement with those predicted from the Hall effect and conductivity data. The Hall mobility values obtained on single crystal filaments of n- and p-type germanium are

$\mu_p = 1{,}700$ centimeters per second per volt per centimeter
$\mu_n = 2{,}600$ centimeters per second per volt per centimeter

Note that in germanium electrons drift about 1.5 times as rapidly as do holes. The agreement between Hall effect mobility and drift mobility is a very gratifying confirmation of the general theoretical picture of holes drifting in the direction of the electric field.

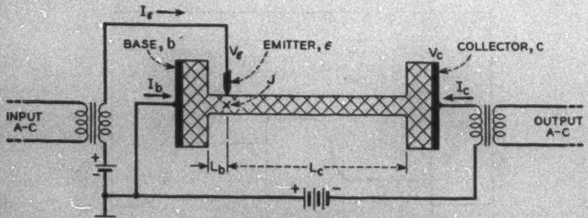
From other experiments[9] in which the single collector point is replaced by two closely spaced metal points, used as probes to measure the potential drop between the points, it is possible to deduce that in n-type germanium practically all the emitter current is due to hole injection; in a p-type sample it was found that 60 per cent of the emitter current was due to injected electrons and 40 per cent due to holes. From these experiments it could also be deduced that the lifetime of holes injected into a particular n-type sample was 9×10^{-7} seconds, while the life time of electrons injected into a p-type sample was 4×10^{-7} seconds. By repeating the experiments with various filamentary samples of different cross sections, it was found that holes and electrons combine chiefly on the surface of the germanium. For samples with large cross sections, life times as high as 140×10^{-6} seconds were observed.

In another modification of the experiment, a small potential difference was applied between the two closely spaced test probes and the resulting current measured. In this way the conductivity in the region between the test probes could be measured. It was found that the conductivity increased directly in proportion to the hole current injected by the emitter. For a given emitter current, the increase in conductivity between test points was lessened if these points were farther removed from the emitter or if the drift velocity was decreased by decreasing the potential drop along the filament. From such experiments it was possible to deduce the fraction of the total current in the body of the germanium which is carried by holes and to measure the concentration of holes at any distance from the emitter.

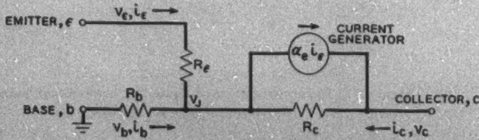
When the experiment was modified again by using one or both of the test points as a collector it was found that the increase in collector current was directly proportional to the hole concentration near the test points. The proportionality constant, however, varies considerably from one point to the next and depends on the treatment given the collector point.

THE FILAMENTARY TRANSISTOR

Figure 2 shows a filamentary transistor and its equivalent circuit. Just as in the type-A transistor, hole injection plays an important role; but the principle of operation is different. One important feature of the type A is the high impedance of the rectifying collector contact which, however, does not impede hole flow, and another important feature is the current amplification occurring at the collector contact. Neither of these features is present in the filamentary type shown. Instead, the high impedance at the collector terminal arises from the small cross section of the filament. The modulation of the output current takes place through the change in body conductivity due to the presence of the added holes, a change which appears to be unimportant in the type-A transistor. In the filamentary type, current amplification is produced by the extra electrons whose presence is required to neutralize the space charge of the holes. In the type-A transistor it is probably also produced by the space charge of the holes but the details of the mechanism are not as easily understood.



(a) FILAMENTARY TRANSISTOR



(b) EQUIVALENT CIRCUIT

Figure 2. Filamentary transistor and equivalent circuit

SOME CIRCUIT ASPECTS OF THE TRANSISTOR

The purpose of this section is to discuss in a general way some circuit aspects of the transistor.[10] It is rather interesting that in order to discuss its circuit aspects, little direct reference to the transistor is necessary. One needs only certain properties of the transistor which are empirically obtainable by measurement; these properties then determine behavior in the manner prescribed by the methods of general network theory. In principle, one needs no knowledge of the physics of the transistor in order to treat it circuitwise; any "black box" with the same electrical behavior at its terminals would act the same way.

A black box is shown in Figure 3 along with the equations describing it. The performance is completely characterized if one knows the voltage and current at each of the two pairs of terminals. Now of these four variables only two are independent, since if any two are fixed, the other two are determined. One can therefore describe the network in terms of any two of the variables, and since there are six possible ways to choose a pair of variables from a set of four, there are six ways of describing the network.

To recall what is done for electron tubes is helpful. In the case of a triode the voltages on grid and plate are usually taken as independent variables; the grid and plate currents are taken as functions of the voltages. It becomes natural then to measure tubes with regulated power supplies, having low impedances to keep the volages constant; and one is then naturally led to describe tubes in terms of admittances. Now the trouble with this scheme for transistors is that many of them oscillate when connected to low impedances, that is, many transistors are short-circuit unstable. To avoid this difficulty it is convenient to measure with high impedances in the leads; the analytical counterpart is to regard the currents as independent variables, leading naturally to a description of the transistor in terms of impedances, as shown in the figure.

This description by open-circuit impedances happens to be a good one for many purposes, but there is nothing final or unique about it. In fact at high frequencies one of the other descriptions becomes more convenient.

By interpreting the $\mathcal{Z}$ equations as circuit equations, one is led directly to the first equivalent circuit of Figure 4*a*. A little consideration shows why the $\mathcal{Z}$'s are called open-circuited impedances. For example, if the second mesh is open-circuited, then the equations say that $\mathcal{Z}_{11}$ is the ratio of input voltage to input current, that is, the input open-circuit impedance, while $\mathcal{Z}_{21}$ is the ratio of output voltage to input current, that is, the open-circuit forward transimpedance. Similarly $\mathcal{Z}_{12}$ is the open-circuit feedback transimpedance and $\mathcal{Z}_{22}$ is the open-circuit output impedance.

This equivalent circuit for small signals is only one of many possibilities. Another, which is in fact more frequently used, is shown in Figure 4*b*. It consists of a *T* of resistors, each of which is associated with one of the transistor leads, and a voltage generator in series with the collector lead whose ratio to the emitter current is also of the dimensions of a resistance. The elements of this equivalent circuit are related to the former one by a simple subtraction. The other equivalent circuit in Figure 4*c* is obtained by converting the series voltage generator to the equivalent shunt current generator, whose ratio to the emitter current is now a dimensionless constant designated by *a*.

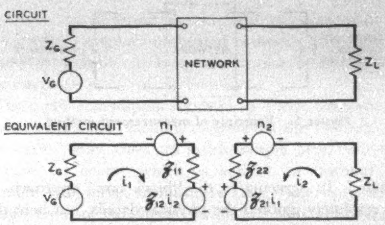


Figure 3. Synopsis of general 4-pole—impedance analysis

Equations:
$$i_1(\mathcal{Z}_g+Z_{11})+i_2Z_{12}=v_G$$
$$i_1Z_{21}+i_2(Z_{22}+\mathcal{Z}_L)=0$$

Circuit determinant:
$$\Delta=(Z_{11}+\mathcal{Z}_g)(Z_{22}+\mathcal{Z}_L)-Z_{12}Z_{21}$$

For stability:
$$\Delta>0$$

Input impedance:
$$\mathcal{Z}_{11}=Z_{11}-\frac{Z_{12}Z_{21}}{Z_{22}+\mathcal{Z}_L}$$

Output impedance:
$$\mathcal{Z}_{22}=Z_{22}-\frac{Z_{12}Z_{21}}{Z_{11}+\mathcal{Z}_G}$$

Operating power gain:
$$G_0=4R_GR_L\left|\frac{-Z_{21}}{\Delta}\right|^2$$

Insertion power gain:
$$G_1=\left|\frac{(\mathcal{Z}_G+\mathcal{Z}_L)Z_{21}}{\Delta}\right|$$

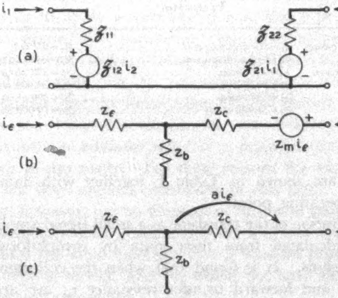


Figure 4. Some equivalent circuits

These circuits, as well as all the other numerous possibilities, are equivalent in the sense that they all give exactly the same performance for any external connection of the unit. These three, however, are particularly well-behaved in that usually none of the circuit elements is negative; they are readily accessible to measurement; the association of the various circuit elements with corresponding regions within the transistor appears to have some physical significance; and finally, the parameters are not too dreadfully dependent on the exact operating point used.

In the choice among various equivalent circuits, it appears that the optimum of convenience is also the one which most closely approaches the underlying physical

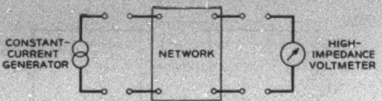


Figure 5. Principle of measurement method

situation. In agreeing to the "black box" approach, we have resolutely ignored the physical details, but here they are presenting themselves in a new way, having sneaked in the back door after we barred the front.

The principle of a method used for rapid measurement of the transistor impedances is shown in Figure 5, illustrating the measurement of forward transimpedance. A pair of terminals of the transistor is driven by a small alternating current of a few thousand cycles from a high impedance generator; the voltage developed is read by a high impedance voltmeter. By calibrating the meter directly in ohms, one can read off the open circuit resistances of the unit as rapidly as one can switch and read meters.

Average values found by this method for the type-*A* transistor are shown in Table I, together with data on the d-c operating point.

Table I. Equivalent Circuit Parameter Values for Type-A Transistor

D-c operating point:	$I_e = 0.6$ milliampere	$V_e = 0.7$ volt
	$I_c = -2$ milliamperes	$V_c = -40$ volts
Circuit parameters:	$r_e = 240$ ohms	$r_b = 290$ ohms
	$r_c = 19{,}000$ ohms	$r_m = 34{,}000$ ohms
	$Z_{11} = 530$ ohms	$Z_{12} = 290$ ohms
	$Z_{21} = 34{,}000$ ohms	$Z_{22} = 19{,}000$ ohms

The operation of the transistor as a small-signal amplifier can be calculated from these data by straightforward circuit analysis. It is found that when the collector resistance r_c and forward transfer resistance r_m are nearly equal, the transistor is broadly like a vacuum triode in which emitter is like cathode, base like grid, and collector like plate.[10] This analogy might be expected from the foregoing physical discussion in which the stream of holes from emitter to collector is broadly like the electron stream from cathode to plate of the tube.

However, this transistor-tube analogy is much less close when, as usual, the forward impedance is considerably greater than the collector impedance. The chief new feature is that the transistor under certain circumstances becomes unstable.

NOISE IN TRANSISTORS

On the circuit representation of noise as well as signal much work has been done by L. C. Peterson.[11] It turns out that in the general 4-terminal network in which we are interested, a complete noise representation for circuit purposes may be obtained by adding two noise generators to the equivalent circuit of four signal parameters, as shown in Figure 6.

These noise representations are on an entirely similar basis to the signal representations. Just as four elements in any independent configuration suffice for signal description, so two noise generators in either series or shunt in any convenient independent locations can be added to account for the noise. All these representations give the same signal and noise behavior for any external connections. Still, some may be better than others in corresponding to the actual physics of the transistor; presumably the better representations will show particularly simple behavior, for example, in their dependence upon the d-c operating point of the transistor. The usual choice puts noise voltage generators in series with the emitter and collector leads, as shown.

If the two noise generators were truly independent physical sources of noise, their outputs would be expected to show no correlation and their noise power contributions would be simply additive. This independence is not usually the case for the type-*A* transistor. By adding the noise outputs and comparing the power in the sum to that in the separate components, H. C. Montgomery found correlation coefficients ranging from −0.8 to +0.4. From this the conclusion can be drawn that the physical sources of noise in these transistors do not act in series with the leads but at least to some extent arise elsewhere in the transistor, contributing correlated noise output to both the generators of the circuit representation.

The study of transistor noise by H. C. Montgomery has shown it to be of two types. One is a rushing sound somewhat similar qualitatively to thermal resistance noise; the other is a frying or rough sound which occurs erratically, usually in the noisier units. The noise power per unit bandwidth varies almost exactly inversely with frequency,[8] being in this respect reminiscent of contact noise.

Since the noise dependence on frequency is known, its level may be given as noise voltage per unit bandwidth at a reference frequency (1,000 cycles). The collector noise usually dominates as far as practical effects on the output are concerned. Representative values are about 100 microvolts per cycle at 1,000 cycles for the collector, and one or two microvolts for the emitter.

The noise voltages depend mainly on the collector direct voltage.[10] While they do vary with the other operating parameter at constant collector voltage, such variations rarely exceed ten decibels, which is much less than the variations with collector voltage.

More important than the actual level of the noise is its relation to thermal resistance noise, which is the ultimate limit to amplification. This relationship is conveniently expressed by means of the noise figure, or number of times noisier than amplified thermal noise in the output of the amplifier. A representative noise figure for the type-*A* transistor at 1,000 cycles is 60 decibels, with individual units ranging from 50 to 70 decibels.

Noise figure formulas for the grounded base, grounded emitter, and grounded collector have been derived.[10] The noise performance of the three connections would usually not be very different if it were not for stability considerations, which may render unusable the generator impedance which would give optimum performance. Mainly on account of stability, the grounded base connection may be said to give the best noise performance, with the grounded emitter running a close second.

The noise figure of any device depends upon the generator impedance out of which it works but does not depend upon the load. Accordingly, there exists an optimum generator impedance which gives the best noise figure of which the unit is capable. This optimum source impedance is best for signal-to-noise performance, not for signal performance alone; hence, as is well known for vacuum tubes, it is usually not a match for the unit, and in general both the resistive and reactive components of impedance may be mismatched to the unit.

For the transistor at low frequencies in the grounded-base connection, reactive effects are negligible and the emitter noise generator may usually be neglected. Under these conditions the optimum noise figure is obtained from a generator of impedance equal to the open-circuit input resistance of the transistor. This may be quite different than the actual working input resistance.

The best operating point for low noise is usually obtained at a moderate collector voltage (20 volts) and a small emitter current (0.5 milliampere).

INDUSTRIAL APPLICATIONS OF THE TRANSISTOR

The well-known vacuum tube had its origin in the communication field and its contributions to the advancement of that field are very well known. Quite a period of time elapsed before the applications of this device outside of the communication field became of real significance. Today, the vacuum tube serves many functions in varied fields and, by and large, does a creditable job. However, there seems to exist a fundamental difference between applications of the vacuum tube in the communication field and in other fields. In the communication field the vacuum tube is the heart and soul of the apparatus, everything else in the equipment being subservient to it. It, therefore, is treated with respect. The operators of the equipment know well its abilities and its limitations and do not expect more performance of it than it can give. In other fields, however, the vacuum tube, in the minds of its users, is relegated to an inferior position. It becomes the servant rather than the master and ofttimes is treated with less respect and its characteristics do not receive the same consideration. If it burns out, its user, rather than accepting this as an expected event, complains bitterly about the annoyance caused and wishes volubly for something that would operate as reliably as an induction motor, that could be abused far beyond its capabilities without instantaneous disastrous results, and which in general was much more reliable.

The transistor, like the vacuum tube, was first conceived in the communication industry. Its origin and development by the Bell Telephone Laboratories is well known. Like the vacuum tube, its application to fields outside of the communication field may be anticipated. In thinking about the characteristics of the transistor and the role it may be called upon to play in applications outside of the communications field, one is struck by two characteristics which seem to provide the possibility of performance not inherent in the vacuum tube. These two characteristics are: first, the transistor should have an indefinitely long life because it employs no heated cathode; and second, it should be possible to make the transistor mechanically very rugged.

There are many applications for a device possessing the characteristics of a vacuum tube which the vacuum tube, as it exists today, does not satisfy simply because it has a filament or heater which is subject to burnout. An example will serve to illustrate this. The operation of certain types of switchgear which are used in connection with the distribution of electric power conceivably could be improved or simplified through the application of vacuum tubes. However, it is immediately apparent that the prime responsibility of switchgear apparatus is that of performance when called upon. Clearly, if it fails in this respect, electric power may be lost to various areas for substantial lengths of time and it requires no stretch of the imagination to see how adversely this would affect the users of such power. Obviously then, switchgear must be reliable in its operation.

The use of vacuum tubes in circuits which control the operation of such switchgear suffers from the fact that such tubes have a finite and relatively short life. A life of 10,000 hours is only slightly over a year's normal operation because switchgear has to be on the job 24 hours a day. One wanting to apply a vacuum tube in this type of service could argue that paralleling two tubes to perform the function of one and replacing these tubes on a maintenance schedule would, for all practical purposes, remove the limitations due to finite tube life, as indeed it would. However, this at once doubles the cost of the tube complement and in addition requires a maintenance operation which is also costly. For these reasons the vacuum tube has not been applied extensively in this field. The transistor, however, has no filament or heater to burn out, and consequently holds promise of being a device which would perform the same functions that a vacuum tube would in this type of service, and yet would not have the difficulty previously mentioned.

Assuming its other characteristics to be equivalent of the

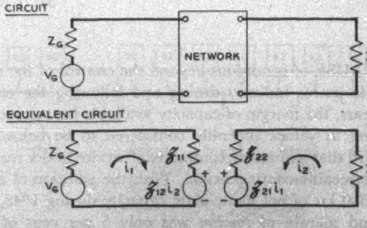


Figure 6. **Synopsis of general 4-pole, including noise**

Equations: $i_1(Z_G+Z_{11})+i_2Z_{12}=v_G\oplus N_1$

$i_1Z_{21}+i_2(Z_{22}+Z_L)=\oplus N_2$

Circled $\oplus$ signs indicate addition with attention to any correlations which may exist between noise generators or mean square additions if no correlation exist

Noise figure $F=1+\frac{1}{4kTBR_G}\left[\overline{N_1^2}+\overline{N_2^2}\left(\frac{Z_{11}+Z_G}{Z_{21}}\right)^2\right]$

vacuum tube which might be applied in this way, the transistor would be preferred because of its freedom from burnout and hence its freedom from design and maintenance difficulties. Many other examples could be given to illustrate this point. However, it seems clear that because of its relatively long life and freedom from burnout, the transistor may well be applied to those industrial fields where reliability is of prime importance.

In many industrial applications, the vacuum tube, if used, is subjected to severe mechanical vibrations or shock. These, in some instances, give rise to microphonic output from the tube which seriously hampers its operation, and in other instances, materially shortens the useful life of the tube. Many cases have already arisen wherein the vacuum tube gave rise to operational troubles due to its inherent sensitivity to mechanical shock and vibration. Of course, in such cases steps can be taken to insulate the tube mechanically, but such steps of necessity increase the cost of the apparatus and also the possibility for trouble. Again it seems clear that the ruggedness which the transistor should possess should make it relatively free from such troubles.

These two factors, long life and ruggedness, are the factors which open to the transistor many possible applications in industrial fields.

As presently developed, the transistor has one drawback which limits its usefulness in many fields. This drawback is its inability to handle power exceeding a fraction of a watt. This characteristic will have to be overcome before its application will be widespread. Another characteristic which limits its application to a degree in the communication field, namely, that of its response at very high frequencies, seems to be of little consequence in the majority of industrial applications. What is needed then, is a transistor or transistor-like device which will handle powers of five to ten watts or more. It is to be hoped, therefore, that those who are working in the development of the transistor will find ways to improve its power handling capacity. When this is done, it is safe to predict that it will be applied in many places to the improvement in performance of the apparatus with which it is associated and will earn a real place in the industrial electronics business.

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Relation of Plant Design to Reserve Capacity

M. J. STEINBERG

BECAUSE of conditions beyond the control of the electric power industry during and following the recent war years, the margin of capacity available for reserve has dropped to values generally considered to be below the standard that will assure continuity of service under reasonably forseeable contingencies. With the addition of some 4,141,500 kw of net name-plate capacity during 1948, the year-end margin of reserve was only 5 per cent of the annual peak demand. The planned addition of some 6,700,000 kw of capacity during 1949 will increase the margin of reserve to an estimated value of but 8 per cent, and with planned capacity additions for succeeding years it is not expected that a satisfactory margin of reserve, which in most areas is now considered to be around 15 per cent, will be available until the end of 1951.

With costs for construction, operating labor, and materials at the highest levels in the history of the industry, coupled with difficulties in attracting equity capital to finance construction programs, planning and design engineers have been directing their main efforts and talents toward keeping investments in new plant capacity as low as possible.

A review of available literature descriptive of thermal plant design clearly indicates a trend towards the installation of single boiler–single turbogenerator for operation as a unit. Adoption of this arrangement is understandable in

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Full text of a conference paper, "The Relation of Thermal Plant Design to Reserve Capacity Requirements," presented at the AIEE Fall General Meeting, Cincinnati, Ohio, October 17–21, 1949.

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light of probable savings in operating personnel and reduction in investment by the elimination of valves, fittings, and piping connections which are relatively expensive for service at high steam pressure and temperature. A further consideration is the fact that the reliability of such equipment approaches and possibly equals that of equipment designed to operate at low and intermediate values of pressure and temperature.

Should a less-expensive, inflexible system be used to increase the reserve capacity of a power plant, or is it more practical to install a costlier, more versatile addition? A study of the plant design and its effect on system reserve requirements is presented with a suggested method of evaluation of plans.

It is presumed that in many instances the choice of pressure-temperature combination, cycle design, and the size of boiler and turbogenerator units is made by an evaluation of differentials in thermal performance and operating costs for labor, materials, and supplies. Too frequently the effect of plant design on system reserve requirements is overlooked or disregarded even though the latter may under some conditions be more important than the differentials in operating costs.

The effect of such factors as the number and size of boiler and turbogenerator units, general arrangement, and design of equipment on the ability of the reserves of the system to maintain an objective degree of service reliability is capable of calculation by the application of the mathematical tool commonly referred to as the "probability method."[1]

The purposes of this article are to illustrate how general plant design, and in particular the interconnection of boiler and turbogenerator units affect system reserve requirements, and to suggest a method of evaluation of these factors.

BASIC DESIGNS

For the purposes of this article it is assumed that a thermal plant with an ultimate capacity of 640 megawatts is to be added to an existing system. Six possible designs, illustrated schematically in Figure 1, are analyzed and described in the following paragraphs.

Case 1. This installation consists of four turbogenerators each rated at 160 megawatts with four boilers of matching capacity arranged for unit operation by the elimination of a common steam header. This design is considered as the base case for reference on the assumption that it represents the current trend of design and that lowest investment per kilowatt of plant capacity is required for a selected pressure-temperature combination. Under this arrangement the outage of one boiler or turbogenerator unit represents a loss of 160 megawatts or one-fourth of the plant capacity. The simultaneous outage of one turbogenerator and one noncompanion boiler represents a loss of 320 megawatts or one-half of the total plant capacity.

Case 1-A. This design is the same as that under *Case 1*, except that a common steam header has been added, the effect of which is to increase the flexibility of the plant since the simultaneous outage of one turbogenerator unit and one noncompanion boiler results in a reduction of only 160 megawatts of plant capacity.

Case 2. The arrangement under this design provides for unit operation of one turbogenerator and two boilers of

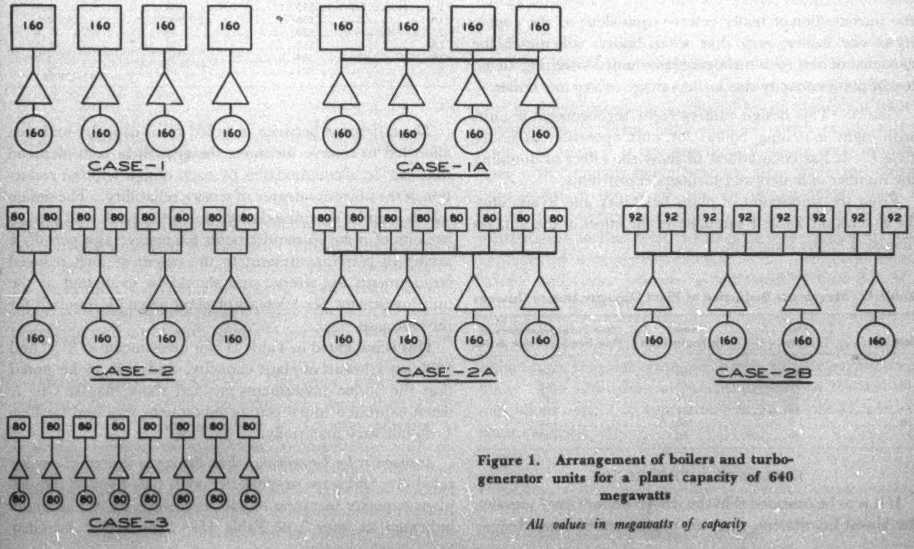

Figure 1. Arrangement of boilers and turbogenerator units for a plant capacity of 640 megawatts

All values in megawatts of capacity

matching capacity. The outage of one boiler represents a reduction of 80 megawatts of plant capacity, while the simultaneous outage of one turbogenerator unit and one noncompanion boiler reduces the plant capacity by 240 megawatts.

Case 2-A. This design modifies that under *Case 2* by the addition of a common steam header. The addition of the steam header does not affect the capacity reduction due to the outage of a single turbogenerator or boiler. It does, however, reduce the loss of capacity due to the simultaneous outage of one turbogenerator and one noncompanion boiler from a value of 240 megawatts to 160 megawatts.

Case 2-B. This design modifies that under *Case 2-A* by the introduction of boiler reserve equivalent to the capacity of one boiler, such that seven boilers will match the capacity of the four turbogenerator units, resulting in no loss of plant capacity due to the outage of any one boiler.

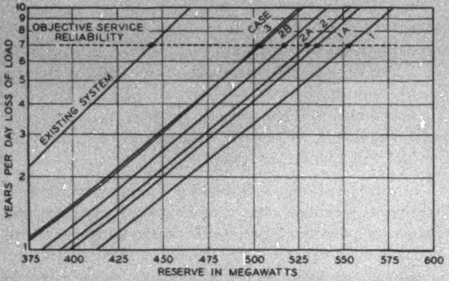

Figure 2. Effect of plant design on system reserve capacity requirements

Calculated on basis of three per cent forced outage rate for boiler and turbogenerator units

Case 3. This design utilizes eight turbogenerator units with eight matching boilers for unit operation as under *Case 1*. It has been added to show the effect of doubling the number of boilers and turbogenerator units.

From the standpoint of plant flexibility and availability for generation Table I summarizes the effect of the outages discussed in the foregoing.

Table I. Megawatts Reduction of Plant Capacity Due to Outages

Case	One Boiler	One Turbogenerator	One Turbogenerator and One Noncompanion Boiler
1	160	160	320
1A	160	160	160
2	80	160	240
2A	80	160	160
2B	0	160	160
3	80	80	160

EVALUATION PROCEDURE

If it is to be assumed that the design under *Case 1* requires the lowest investment, then the evaluation of other designs should indicate what additional investment, if any, could be justified on the basis of any benefits to be derived which are not available with the design under *Case 1*. In the interest of brevity, this has been done by the evaluation of but three factors, which are considered to be predominant, to the exclusion of all others which are considered to be of minor importance. In general, the procedure follows that described in a paper previously presented before the Institute.[2]

The results of the evaluation, shown in Table III, are based on the following points.

On-Peak Reserve Requirements. Systems serving metropolitan areas generally experience their annual peak demands during the winter months and more specifically in December. The installed capacity in excess of the annual peak demand is referred herein as "on-peak reserve." Capacity is added to an existing system primarily to meet the estimated growth in annual peak demand, and to increase the margin of capacity for reserve so that the objective degree of service reliability may be maintained with growth of peak demand. With respect to on-peak reserve requirements, the effect of plant design is illustrated by the curves of Figure 2 which were calculated on the basis of a 3 per cent forced outage rate for the boiler and turbogenerator units.

For an objective service reliability as measured by loss of load averaging one day in seven years, the system reserve requirements and the portion of new plant capacity allocated to system reserve are listed in Table II.

Table II. System Reserve Requirements

Case	Requirements (Megawatts)	Requirements Added by New Plant	
		Power (Megawatts)	Per Cent of Plant Capacity
1	553	108	16.9
1A	536	91	14.2
2	530	85	11.8
2A	517	72	11.3
2B	504	59	9.2
3	503	58	9.1

The difference between installed plant capacity and that allocated to reserve measures the growth in peak demand that can be accommodated by each design without reduction of the objective degree of service reliability. The design which permits accommodation of a larger peak load growth because of reduced requirements for reserve also permits a saving in plant investment to the extent of such reduced requirements for reserve and should be evaluated at the unit investment per kilowatt of plant capacity required for the base case.

This is indicated in Table III for investments at $150 and $200 per kilowatt of plant capacity, and it is to be noted that the added investments justified above that for *Case 1*, when expressed in per cent of investment required for *Case 1*, do not vary materially.

Availability for Generation. For the same degree of service reliability and same on-peak demand, *Case 1* would require plant capacity in excess of 640 megawatts by the amounts indicated as item 2 of Table III. The larger installed

Table III. Evaluation of Designs for a 640-Megawatt Thermal Plant

Case	1	1A	2	2A	2B	3
1. Incremental on-peak reserve capacity requirements at three per cent forced outage rate (in megawatts)	108	91	85	72	59	58
2. Reduction in reserve capacity requirements (*Case 1* as base) (in megawatts)		17	23	36	49	50
3. Capacity equivalent of increased availability of 160 megawatts for three months per year (in megawatts)					40	
4. Total reduction in capacity requirements (*Case 1* as base) (in megawatts)		17	23	36	89	50
5. Value of reduction in capacity requirements						
(*a*). For plant investment at $150 per kilowatt (in thousands of dollars)		2,550	3,450	5,400	13,350	7,500
(*b*). For plant investment at $200 per kilowatt (in thousands of dollars)		3,400	4,600	7,200	17,800	10,000
6. Credits to *Case 1* for increased generation due to larger installed capacity requirements						
(*a*). Increase in generation at 75 per cent output factor $\times 10^6$ kilowatt-hours		13	135	124	261	294
(*b*). Annual fuel savings due to increased generation (in thousands of dollars)		19	203	186	392	441
Differential heat rate at 5,000 Btu per kilowatt-hour						
Fuel priced at $0.30 per million Btu						
(*c*). Credit to *Case 1* at 6.25 times annual fuel saving (in thousands of dollars)		118	1,266	1,164	2,447	2,756
7. Justified added investment above *Case 1* for plant investment at $150 per kilowatt						
(*a*). Total (in thousands of dollars)		2,432	2,184	4,236	10,903	4,744
(*b*). Per kilowatt of plant capacity		$3.80	$3.40	$6.68	$17.00	$7.40
(*c*). Per cent of investment for *Case 1*		2.5	2.3	4.4	11.3	4.9
8. Justified added investment above *Case 1* for plant investment at $200 per kilowatt						
(*a*). Total (in thousands of dollars)		3,282	3,334	6,036	15,353	7,244
(*b*). Per kilowatt of plant capacity		$5.13	$5.20	$9.40	$24.00	$11.30
(*c*). Per cent of investment for *Case 1*		2.6	2.6	4.7	12.0	5.7

capacity requirements for *Case 1* will, however, permit proportionately increased generation. This is indicated as a credit to *Case 1* by item 6 of the same table. Availability for generation was based on scheduled overhaul requirements of two months outage every four years for each turbogenerator, and one month annually for each boiler in the system.

Off-Peak Reserve Requirements. The term "off-peak" has reference to the period approximately from June 15 to September 15, during which it is common practice to schedule overhaul of equipment commensurate with reduced levels of peak demand in this period. Many systems, however, are experiencing rapid growth of summer peak demands making it difficult to accommodate requirements for overhaul. Continuation of this trend will soon make necessary the addition of capacity for overhaul purposes.

In this connection the design under *Case 2-B* offers advantages not available under the other design. For example, in *Case 1*, outages for overhaul will result in a loss of 160 megawatts of plant capacity for five months in each year. For *Case 2-B*, this outage is reduced to two months. It follows, therefore, that there is a differential gain in availability of 160 megawatts of plant capacity for three months during which additional outages for overhaul elsewhere on the system can be accommodated.

A capacity of 160 megawatts which is available for three months in the year is considered equivalent to 40 megawatts which is available year round and is so indicated as item 3 of Table III.

CONCLUSIONS

Although adoption of the single boiler-single turbogenerator design for unit operation will tend towards the least investment for plant capacity, it does not necessarily represent the most economical choice when considered in relation to basic requirements for system reserve, overhaul requirements, and availability of plant capacity for base-load operation.

The effect of connecting boilers and turbogenerator units through a common steam header reduces the requirements for system reserve, while the installation of boiler reserve with a common steam header increases the availability of plant capacity in addition to reducing the requirements for system reserve.

It is recognized that acceptance of the results presented in this article is conditioned upon acceptance of the method of evaluation employed and the assumptions upon which it is based. It is believed, however, that comparable results will be obtained by any other acceptable method of evaluation.

All possible designs have not been considered among which might be included the currently popular reheat-regenerative cycle. It is more than of passing interest to note that approximately 2,500,000 kw of capacity is under construction or being contemplated which employs this cycle. Because it is not practical to design such installations with common steam headers, they have the objections noted in the article for the design under *Case 1*. Whether the five per cent gain in thermal efficiency which is attributed to this cycle is sufficient to overcome the advantages of a regenerative cycle with a common steam header and boiler reserve, as indicated by *Case 2-B*, is a matter worthy of more serious consideration in the design of a plant.

A five per cent gain in thermal efficiency is equivalent to a reduction in heat rate of approximately 500 Btu per kilowatt-hour. The additional investment justified by the fuel savings above *Case 1* is approximately $6.20 per kilowatt of plant capacity.

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Papers Digested for Conference on Electronic Instrumentation

These are authors' digests of most of the papers presented at the second annual Conference on Electronic Instrumentation in Nucleonics and Medicine, sponsored jointly by the AIEE and the Institute of Radio Engineers, New York, N. Y., October 31, November 1–2, 1949. The papers are not scheduled for publication in AIEE Transactions or AIEE Proceedings, nor are they available from the Institute. However, published proceedings of the conference will be obtainable in the near future through R. S. Gardner, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. The price will be $3.50 to both members and nonmembers.

Low-Frequency Spectrography—Some Applications in Physiological Research; *R. R. Riesz (Bell Telephone Laboratories, Inc., Murray Hill, N. J.).*

The spectrographic study of low-frequency vibrations is of very broad interest in the field of communication research and development. The technique of the sound spectrograph developed at the Bell Telephone Laboratories, whereby graphical portrayals of spectra in the audiofrequency region are produced, has been extended to include the low-frequency region from 0.5 to 35 cycles per second.

Low-frequency spectrography has many applications to research in engineering and the physical sciences as well as in several branches of physiology. Some preliminary experimental work in three such branches has been done. The work on EEG was carried out with the co-operation of Dr. Margaret Lennox of the Yale University School of Medicine.

The sound spectrograph was designed to produce graphical portrayals of spectra for frequencies in the audio range up to 3,500 cycles per second. To extend the frequency range of this device to portray spectra in the region from 0.5 to 35 cycles per second required the design and construction of a special magnetic recorder. The low-frequency wave to be studied is recorded with the magnetic medium moving past the recording head at the slow speed of 0.16 inch per second. After recording, the waves are reproduced at a speed 100 times faster or 16 inches per second. The original frequency range 0.5 to 35 cycles per second is thus multiplied up to the range 50 to 3,500 cycles per second enabling the waves to be suitably analyzed by the sound spectrograph. The speed-up of 100 times also compresses the time scale so that the original wave, recorded in 240 seconds, is reproduced in 2.4 seconds. The original cardiac or EEG waves are picked up by electrodes on the surface of the body and amplified in the usual manner.

Three-dimensional plots of the spectra, in which the three orthogonal axes are frequency, amplitude, and time, are useful in visualizing the time fluctuation of the frequency composition of brain waves. The 100-fold frequency multiplication moves the frequencies of the heart, brain, and muscle waves up into the audible region. The reproduction of such waves shows the correspondence between the acoustic properties of the waves and their spectrographic pattern. Movies have been made showing the fluctuation with time of the spectra of EEG waves, the original time scale being speeded up by a factor of four. These movies were made by photographing on successive frames of a film, amplitude-frequency curves of the brain waves made every 0.25 second during the course of the waves and projecting the film at 16 frames per second. No attempt at clinical interpretation of any of the experimental results is made in this paper.

Electrical Methods of Blood-Pressure Recording; *Frank Noble (School of Electrical Engineering, Cornell University, Ithaca, N. Y.).*

The objectives of this paper are

1. To discuss the errors inherent in any displacement gauge used for dynamic blood-pressure recording.
2. To discuss methods of minimizing these errors in diaphragm-type electric displacement gauges suitable for blood-pressure recording.
3. To discuss auxiliary amplifying and recording apparatus with regard to accuracy and to electric circuit problems.
4. To suggest the use of electric differentiating and integrating circuits for the study of pressure wave shape and for the easy evaluation of average pressure.

The conclusions are

1. The fluid flow in the needle is not viscous. Therefore the resistance in the analogous electric circuit is not a constant and the usual electric circuit methods and equations do not apply to the performance of the hydraulic system of any displacement-type manometer.
2. For a given needle size, the natural frequency of the hydraulic system is proportional to the square root of the pressure-volume ratio and is virtually independent of the diameter of the diaphragm or the length of the diaphragm chamber, within the limits of usual geometry.
3. The damping is also virtually independent of the diaphragm diameter and chamber length, for usual geometry.
4. Theoretically speaking, the variable capacitance displacement gauge is the most sensitive and accordingly the best gauge for use with electric recording manometers.
5. The most satisfactory system of amplification for the capacitance gauge is an a-c bridge used with a carrier system.
6. Direct-writing oscillographs possess sufficient response speed for ordinary purposes, and are much more convenient to operate than are photographic systems.
7. Differentiating circuits emphasize the harmonic content of the pressure wave and thus provide a more searching test of wave shape than does the pressure wave itself.
8. Integrating circuits provide average pressure automatically, eliminating the need for graphical computation from the pressure trace.

A Stable D-C Amplifier for Biological Recording; *Harry Grundfest (College of Physicians and Surgeons, Columbia University, New York, N. Y.).*

D-c amplifiers are obligatory for bioelectric recording in a number of applications. Among these are situations which present in addition requirements of high input impedance, high-frequency response, but low sensitivity, and others where the frequency response of the amplifier may be moderately good (flat to 15–30 kc) but the sensitivity must be adequately high to observe 20–50-microvolt signals. D-c amplifiers are also advantageous but not obligatory in a variety of other applications when transient responses are observed in the presence of large, occasional signals due to electric stimuli, or to contact variation due to movements. Bioelectric amplifiers must be differential to as high a degree as possible to reject a variety of extraneous signals.

Completely line-operated d-c amplifiers are advantageous in that they do away with bulky arrays of batteries. The low impedance of electronically regulated power supplies also permits use of several amplifier channels from a single power supply, thus increasing economy of space over battery-operated equipment.

In a consideration of the various methods of coupling, the advantage of coupling through a cathode follower whose load is returned to a negative supply should be noted. In considering the various expedients for stabilization against potential changes in the cathode-ground circuit, it should be pointed out that a grid-ground variation of about 50 microvolts per minute is a minimum for the contact potential variation in the pickup electrodes.

A completely line-operated d-c amplifier (provided, at will, with one *R-C* coupling) uses regulated heater and high-voltage supplies, and special balancing circuits against supply variations. It has a differential formation ratio of about 1:100,000; a sensitivity about one microvolt per minute on the cathode-ray tube face; handles up to 500 millivolts in three discrete gain ranges; has a frequency response flat to about 30 kc per second; and instability of less than 40 microvolts per minute. Figures quoted are for two units that operate from one power supply and use unselected tubes.

A 25-Channel Recorder for Mapping the Electric Potential Gradients of the Cerebral Cortex: Electro-iconograms; *Dr. John C. Lilly (E. R. Johnson Foundation, University of Pennsylvania, Philadelphia, Pa.).*

The cerebral cortex and the rest of the brain generate electric potentials, which at a given location vary with time. The complex wave forms can be related, in a general way, to the physiological and the psychological activities of the animal. In any given volume of the brain, the wave forms generate traveling and fixed 2-dimensional patterns. We are making a first attempt to record some cross sections of these patterns by a 2-dimensional array of electrodes in the brain and a corresponding array of intensity-modulated light sources photographed with a motion picture camera.

The patterns most easily seen are of two types: those fixed in the brain co-ordinates but oscillating with respect to time; and those traveling with respect to the brain coordinates and showing fine "structure" along the axis of travel. With certain restrictions, these two types can be seen with suitable arrays of electrodes, amplifiers with time constants of the order of one second, and suitable arrays of recorder elements.

The present apparatus is called the "bavatron," from the initials of the phrase "brain activity visualization in areas" plus the suffix, "-tron," meaning "device." The bavatron consists of 25 electrodes, 25 amplifiers, 25 circular light sources, and a motion-picture camera. The electrodes on the brain and the lights in the camera field are in corresponding positions in two (five-by-five) square arrays. The potential change at each electrode drives one light through one amplifier. As the potential under a given electrode varies, the intensity of the corresponding light varies in an approximately logarithmic fashion with respect to the input potential changes. The amplifiers have a pass band from about 0.5 cycle per second to 700 cycles per second. The present motion-picture camera is of the high-speed type, 64 to 128 frames per second.

The resulting records, called electroiconograms (EIG), are projected at 16 frames per second (time scale expansion of 4x to 8x). The viewing process is aided by projecting a small image (visual angle of 1.0 degree to 0.1 degree) of the whole array viewed through a red filter (Wratten *71A*, pass band above 610 millimicrons). Under these conditions, traveling or fixed patterns can be easily seen in the records, despite the relatively small number of sources (25) contributing to the patterns.

Two types of record are being worked on: variable density and variable area. The records taken with the variable density system show moving patterns on the cortex but are not easily measured for quantitative data. The variable area records can show moving patterns and, with prints from the 16-millimeter film enlarged several times, can be used easily for quantitative studies by measuring the relative sizes of the circular images of the light sources.

The records of the cortical activity taken on the exposed brains of animals show traveling patterns in the unanesthetized state and also show, in the anesthetized state that the bursts of activity known as "nembutal spindles" travel in definite paths over the cortex and have definite cross-sectional "shapes" which are maintained for short distances of travel.

Medical Application of Ionizing Radiations, *Edith H. Quimby (Radiological Research Laboratories, Columbia University, New York, N. Y.).*

Medical applications of ionizing radiations may be considered under three main topics, treatment, diagnosis, and medical research. The ionizing radiations which are chiefly or potentially useful in these fields are X rays; alpha, beta, and gamma rays from naturally or artificially radioactive substances; and neutrons. Of these, alpha rays and neutrons are at present of little significance; the use of X rays and gamma rays is widespread, and beta rays are beginning to be used to a certain extent.

In therapy, the purpose of employing any of these agents is to bring about changes in certain abnormal or diseased groups or types of cells, without producing excessive damage to normal structures or to the organism as a whole. In some types of disease, or in accessible lesions of other types, it is sometimes possible to do this. It may be accomplished by X rays from outside the body, by intracavitary or interstitial radium or radon sources or (in a very few instances) by the internal administration of radioactive isotopes, or by combinations of these. The main field of radiation therapy is in the treatment of cancer and allied diseases, and constant efforts are being made to find new and improved methods of employing these radiations.

In diagnosis it is generally not desired to produce any change, but to ascertain whether an abnormal condition exists, or to differentiate between possibilities when there is known to be disease. The diagnostic uses of X rays in radiography and fluoroscopy are well known. Among the artificially radioactive isotopes there are a few whose behavior in the body has made it possible to use them as the basis for diagnostic tests. Those most useful at the present time are radioactive sodium, radioactive iodine, and radioactive phosphorus.

In medical research, any experiment which leads to a better understanding of the behavior of the living organism may be important. In this field, radioactive isotopes have a tremendous value. Almost any substance taken into a living organism can be "labelled" by having a part of its atoms made radioactive. This is usually done by incorporating the radioactive isotope into the material during its synthesis. The uptake, distribution, intermediary chemistry, final deposition, and elimination of many elements in many forms have been studied in this way. Data have been obtained concerning membrane permeability, ion exchange, rate and volume of blood flow, and so forth. By placing tissue or other specimens containing radioactive material in contact with a photographic plate, "radioautographs" are made, which graphically show the microscopic distribution of the active material.

An Automatic Isodose Recorder; *Gerald J. Hine (Massachusetts Institute of Technology, Cambridge, Mass.).*

An instrument has been constructed which automatically measures and records the lines of constant radiation intensity (isodose curves) around any gamma-ray emitter. The 3-dimensional radiation field of extended gamma-ray sources can be investigated for the first time with a high accuracy and good resolution. Furthermore, the instrument provides the means to study the influence of a scattering medium, like water, on the dosage distribution.

A scintillation counter, consisting of a calcium tungstate crystal together with a light conducting quartz rod and a *1P21* photomultiplier tube is used as gamma-ray detector. A small cylindrical crystal one-eighth inch in diameter and one-eighth inch high shows equal efficiency for radiation incident from any direction. Its high gamma-ray sensitivity provides a sufficiently high counting rate, even at intensities as low as ten roentgens per hour.

In order to record isodose lines within a selected plane, the gamma-ray source is rotated about an axis perpendicular to this plane. The scintillation counter moves within this plane radially with respect to the rotating source. The radiation intensity as seen by the detector controls its movement through a servomechanism. An increase in radiation intensity due to the rotation of the source causes the detector to move away from the source; a decrease in intensity brings it closer. Hence, the detector is always forced to follow a line of constant radiation intensity. A turntable rotating synchronously with the source and a pen translating simultaneously with the detector permit the continuous recording of the isodose curves.

Isodose curves representing different field intensities can be selected within a plane. Furthermore, by recording corresponding isodose curves in various planes one can obtain 3-dimensional isodose surfaces.

A fundamental problem of great importance for radiotherapy, the radiation field of single, linear radium tubes has been investigated. According to the different construction of the two ends of commonly employed radium tubes with 0.5-millimeter Pt filtration, the intensity distribution around the two ends of each tube has been found to differ considerably. Although autoradiographic methods had indicated these results, all dosage determinations have been based so far on mathematically constructed curves which do not consider these irregularities.

The influence of increasing Pt filtration, the uniformity of the radium salt distribution in the tubes, and isodose curves of odd geometric configurations of different extended gamma-ray sources have been studied. With the instrument the results are obtained in very short time, while other methods, so far as they can be applied at all, are very tedious.

The Measurement of Low-Energy Beta Ray Emitters—Ionization Chamber Techniques*; *Norman A. Bailey (Radiological Research Laboratory, Columbia University, New York, N. Y.).*

This article is concerned with methods for the measurement of low-energy beta ray emitters at various levels, and the assay of both liquid and gaseous samples is discussed—also, the design of chambers which are suitable for this purpose. An easily reproducible geometry and an absolute determination of ionization current are very important. The minimum amount of radioactivity measurable with these chambers is in the case of liquids about one microcurie and in the case of gases about 10^{-10} curie. Tabulated data for 10^{-9} curie of $C^{14}O_2$ show that with this amount of radioactive carbon, readings can be duplicated over a "period of days" with a maximum error of about two to three per cent and a probable error of somewhat better than one per cent.

Both chambers are "windowless" and therefore with a given geometry a maximum number of electrons is utilized in producing ionization. The setup for gases involves two chambers connected in such a way as to cause the effect of background radiation to cancel itself while the radioactive sample causes ionization in one of them.

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* This document is based on work performed under contracts W 31-109 Eng-14 and AT-30-1-GEN-70 for the Atomic Energy Commission.

Proportional Counters for the Measurement of Soft Radiation; *C. J. Borkowski* (*Oak Ridge National Laboratory, Oak Ridge, Tenn.*).

Proportional counters have been developed for precision counting of both soft and hard radiation. Voltage plateaus from 200 to 400 volts in length with slopes of less than one per cent per 100 volts have been obtained in the proportional region.

Since at gas amplifications of 10,000 a single ion pair can be detected, the sensitivity of the proportional counter and Geiger-Müller counter are identical.

Continuous gas flow proportional counters with 50 per cent geometry allow the measurement of soft radiation with no window or air absorption. The soft betas from H^3 for example can be counted from solid sources of this activity. Flow counters of this type have been operated for three years with no change of characteristics. Since the counter is operating in the proportional region, some discrimination against background pulses is possible. For example, a sample of Fe^{55} which emits soft X rays gave a counting rate equivalent to background when the integral counts were taken. The same sample gave a counting rate 30 times the background when only pulses lying in a small energy interval were counted.

A beta proportional counter having 100 per cent geometry has been used for the determinaton of absolute disintegration rates of beta emitters.

The continuous pulse height distribution from a proportional counter makes it necessary to use an amplifier which will accept a wide range of input signals without introducing spurious responses and without blocking. An amplifier with a one-millivolt input sensitivity and a rise time of about 0.5 microsecond and a fall time of five to ten times the rise time is used.

Small Geiger Counters for Biological Applications; *C. V. Robinson* (*Biophysical Laboratory, Harvard Medical School, Cambridge, Mass.*).

There are several types of small Geiger counters which would be useful as *in vivo* detectors in physiological experiments. For example, a counter which would go on the end of a stomach tube, or one small enough to be inserted in a vein.

Probing counters suitable for the localization of brain tumors with the aid of radiophosphorous have been built, and successfully used over a period of 16 months at the Massachusetts General Hospital by Drs. B. Selverstone and W. H. Sweet.[1]

Satisfactory small counters cannot be made by using the usual mixtures and sizes of wire employed in the making of standard size counters. A study of optimum conditions for mixtures of ether-argon[2] and ethyl acetate-argon showed that small counters require a small wire and a high pressure mixture. As an example, a 3-millimeter diameter counter may be made to operate well with a 0.001-inch wire and a mixture of 2.5 centimeters of ethyl acetate and 2 atmospheres of argon.

For probing in the brain it is desirable to have a counter which has: a diameter of two or three millimeters for a length of more than eight centimeters; is sensitive for a length of one or two centimeters near the tip; and has a grounded metal casing so as to be safe electrically and mechanically.

A pair of 3-millimeter diameter brain probing counters with ethyl acetate-argon filling were built and are still operating satisfactorily after eight months of use. Two similar counters of 2-millimeter diameter have operated satisfactorily for two months. A cathode follower circuit is used between these counters and the scaler to permit operation near threshold.

Patients who are to undergo a brain tumor operation are given one to four millicuries of P^{32} from 24 to 48 hours before the operation. After the brain has been exposed the tumor is localized by counting for one-half minute or so in various suspected regions of the brain. Since tumor tissue takes up from 5 to 35 times as much P^{32} as normal brain tissue, a definite indication is usually obtained.

The experimental and applied work which has been done with small Geiger counters indicates that it would be practicable to take counters which are better and smaller than the ones built so far.

This work was supported in part by the Office of Naval Research and by the Atomic Energy Commission.

REFERENCES

1. Location of Brain Tumors by Radioactive Phosphorous, **B. Selverstone, A. K. Solomon, W. H. Sweet.** *Journal*, American Medical Association (Chicago, Ill.), volume 140, May 21, 1949, pages 277–8.

2. A Study of Small Ether-Argon Geiger-Müller Counters, **C. V. Robinson, R. E. Peterson.** *Review of Scientific Instruments* (New York, N. Y.), volume 19, 1948, pages 911–14.

Phosphors for Scintillation Counters; *R. H. Gillette* (*The Laboratory of the Linde Air Products Company, Tonawanda, N. Y.*).

Of the many hundred phosphor systems which are known, only a handful—a few condensed ring organic compounds of which anthracene appears to be the best, some thallium activated alkali halides, calcium and cadmium tungstates, fluorite, cadmium sulfide activated with silver, and perhaps a few others—have proved useful as scintillation counter phosphors. That this is still true in spite of the extremely intensive search for others is probably to be explained by the rather rigid conditions which must be satisfied by a successful phosphor crystal; in addition to being obtainable in reasonably large single crystals of at least fair optical quality, the ideal scintillation counter crystal should show the following characteristics:

1. Complete absorption of radiation to be detected.
2. Maximal conversion of incident energy to light.
3. Complete transparency to and no entrapment of luminescent light.
4. Instantaneous emission of luminescent radiation.
5. A wave length distribution of luminescent output that fits the detector.
6. Proportionality between pulse height and particle energy.
7. No temperature dependence of luminescence.
8. Mechanical strength and chemical inertness satisfactory for the application at hand.

Since it appears that the advantages of scintillation counters are most apparent in gamma ray detection, the degree to which the actual phosphors approach the ideal is best discussed for this application. The tungstates possess the highest gamma ray absorption due to large density and elements of high atomic number; the organics have absorption coefficients some seven times smaller with other phosphors intermediate. Apparently no phosphor crystal yet studied has converted more than about 30 per cent of the incident gamma energy into light and most are less efficient; the organics show about 1 per cent to 2 per cent energy conversion; the tungstates about 4 per cent; and sodium iodide, about 5 per cent. In order of decreasing average pulse size from a given source the phosphors are: NaI(T1), anthracene, the tungstates, naphthalene. Although powdered phosphors scatter a great deal of the luminescent radiation, most of the single-crystals used are almost nonabsorbing. However, serious light losses can occur due to Fresnel reflection which tends to entrap a portion of the radiation within the crystal. The fraction so entrapped depends on refractive index and, for a rectangular parallelepiped, becomes 70 per cent for $CdWO_4$, 56 per cent for $CaWO_4$, 41 per cent for KI(T1), and 34 per cent for anthracene. Part of this can be recovered by suitable design. Anthracene, NaI(T1), and $CaWO_4$ all emit in the blue and fit the *1P21* photomultiplier tube sensitivity curve; $CdWO_4$ emits in the green and is better suited to the *5819;* naphthalene needs a tube with some ultraviolet sensitivity (*1P28*); CdS requires a red sensitive tube such as the *1P22.* There appears to be a wide variation in time required to release the luminescent light in the different phosphors, but most are fast compared to Geiger counters. The organics, with decay times of the order of 10 to 100 millimicroseconds, appear to be faster than the inorganic phosphors the decay times of which vary from perhaps 0.25 to 100 microseconds. Most of the currently used crystals show long phosphorescence when exposed for some time to an intense radiation field; only $CdWO_4$ seems free of these effects. Phosphorescent decay lasting months and accompanied by sensitivity to daylight during this period has been observed in $CaWO_4$ after intense beta bombardment. Several organics, CdS, $CaWO_4$, and NaI(T1) have been shown to yield pulses the average height of which is proportional to the incident quantum energy, and the other crystals probably do as well. The tungstates have the best chemical resistance, mechanical strength, and among the best temperature coefficients; the organics tend to sublime at room temperature or above and are not chemically inert; NaI(T1) is etched by the moisture in ordinary air and must be protected from it. It is generally possible on the basis of these properties to pick out a phosphor which will solve a specific problem.

Solids for Radiation Detection; *Dr. R. M. Lichtenstein* (*General Engineering and Consulting Laboratory, General Electric Company, Schenectady, N. Y.*).

The possibility of using the photoconductivity effect in alkali halide crystals for the measurement of radiation dosages ranging from 0.001 to 1 roentgen has been explored.

A brief description of the photoconductivity effect is as follows: Alkali halide crystals are good insulators even when illuminated with light whose frequency may range from the infrared to the near ultraviolet. However, if the crystal was previously exposed to high-energy radiation, for example, gamma rays, it conducts when illuminated with light in a suitable wave length band, for example, around 620 millimicrons for KBr crystals. The crystal ceases to conduct after a definite amount of charge has been transferred. This charge is proportional to the dosage of high-energy radiation over a range exceeding three decades. It is also proportional to the area of the electrodes and to the applied voltage, inversely proportional to the square of the electrode separation, and independent of the intensity of illumination. The intensity affects only the speed of the charge transfer.

It was found that in KBr crystals with an electrode area of approximately one-half square inch, an electrode separation of one-fourth inch, and an applied voltage of 300 volts, the charge is of the order of 10^{-10} coulomb for a dosage of one roentgen of radium gamma rays. One of the crystal electrodes may be connected to the input of a d-c amplifier. For an input capacity of the order of 10^{-11} farad, the charge of 10^{-10} coulomb will produce a voltage swing of the order of ten volts. Thus a rather simple amplifier is good enough to measure dosages down to one milliroentgen, especially since even with small light sources, the charge transfer can be completed within approximately one second, so that stability requirements need not be stringent.

The measurement of a dosage may be postponed for several days, that is, the activation produced in the crystal by the high-energy radiation is not subject to appreciable decay. After a dosage has been measured the crystal is again ready for use. Drawbacks of this type of radiation dosage meters are chiefly that the sensitivity varies from crystal to crystal and that the calibration depends on the wave length of the activating radiation especially in such high atomic weight substances as KBr. The good features are simplicity, ruggedness, small size, wide range, sufficient sensitivity for health protection service, proportionality between dosage and indication, sufficient permanence of activation.

Some Design Features of Electrical Counting Systems; *N. F. Moody (National Research Council, Chalk River, Ontario, Canada).*

A high degree of instrumentation is necessary in the interests of efficiency, for automatic measurements or multiple simultaneous measurements economize manpower. In a project of limited size, such as the National Research Laboratories at Chalk River, Ontario, Canada, the degree of such instrumentation is set by the available maintenance effort and so is inversely proportional to fault frequency and ease of repair. Some increase in capital equipment costs is justified in exchange for reduced maintenance overheads and improved efficiency of research.

The basic units designed for high-speed scaling counters may be combined in six standard assemblies, giving if required a resolving time of 0.25 microsecond, and completely automatic counting and recording. The most elaborate assembly is a pulse amplitude analyzing counter with from 6 to 60 separate channels.

The design features include:

1. Circuits permitting wide latitude in tube characteristics.
2. Tubes of the long life types, operating under carefully controlled conditions.
3. All components meet appropriate JAN specifications.
4. Strict engineering practice is followed, particular attention being paid to limiting the rise of temperature.

Several unusual circuits may be mentioned, as noted in the following.

The couplings between the binary stages in the "high-speed (0.25 microsecond) scale of 8," use pulse transformers, which generate, from the high rate of change of cathode current, sharp triggering pulses.

The "standard decade" has a constant resolving time irrespective of cyclic condition. Neon indicators are controlled via diodes which allow a strike/extinction voltage ratio of four instead of the more usual two. The higher ratio ensures reliability.

A scale of 16 minus 6 is used. The feedback is applied via biased diodes, so that feedback loops are isolated except during retrip. This maintains constant resolving time, allows higher operating speed, and gives positive operation. Binary pairs use bottomed pentodes, the anode voltage levels during conduction and cut-off then being substantially tube independent.

A "Geiger preamplifier" employs a circuit with logarithmic input-voltage/output-current relationship. After a discharge the Geiger wire potential recovers exponentially, and a given fractional recovery results in a nearly constant output-current change irrespective of the discharge magnitude. In this way output pulses are of constant amplitude, dead time is always held below 100 microseconds, and is independent of input pulse amplitude over the range 0.05 to 50 volts.

"Pulse amplitude measurements" require a circuit which trips at a precisely determined constant level. The precision maintained sets the minimum useful channel width in multichannel analyzers. The circuit developed depends on two diodes with contact potentials in opposition. This largely compensates small voltage changes on the heaters and also tube aging.

Desirable Improvements in Nucleonics Instrumentation*; *J. B. H. Kuper (Brookhaven National Laboratories, Upton, N. Y.).*

Many of the difficulties that plagued nuclear instruments in the years immediately following the war have been overcome, and the commercially available products are now generally far better engineered, but the quality of the components is still not too good.

In the field of personal monitoring equipment, the chief needs are for better means of measuring neutron exposures (fast and slow) and ionization chambers which will respond to various types and energies of radiation more nearly as the human body does. In the case of portable survey instruments we believe that the portable Geiger-Müller counter instruments should be used primarily for roughly locating areas to be studied and that the ionization chamber instruments be used for quantitative work. The latter suffer somewhat from lack of a window material for use with alpha particles which will be sufficiently strong and moisture-resistant, and give trouble with short battery life. Sealed chambers for gamma and hard beta rays give relatively little trouble, but portable instruments for neutron work are not yet available in satisfactory form.

We believe that the importance of the Geiger-Müller counter in research work is diminishing and that proportional and scintillation counters will be of greater interest. To take full advantage of the selectivity of these counters we need better high-voltage supplies and fast amplifiers combining exceptional gain stability with unusual freedom from overload effects.

Also, we find need for pulse height analyzers (kicksorters) of both the multi-channel and single-channel types. These might be of the conventional type or, perhaps, we can hope for special beam deflection tubes to do the job for us. In addition we will need faster scalers.

With respect to the tendency to add "gadgets" to commercial counting equipment, we believe that decade scalers are usually more trouble than they are worth, since they seem inevitably to require more servicing and the extra convenience in interpolation is seldom really useful. Counting rate meters are useful primarily where it is desired to record a varying activity level over long periods, or in portable equipment. They are not good for making quick rough measurements.

Criteria in the Selection of Radioisotopes for Industrial Use; *Eric T. Clarke (Tracerlab, Inc., Boston, Mass.).*

Radioactive isotopes daily are becoming more and more important in industry, since the advent of the nuclear chain-reacting pile has made possible their large-scale production with a resultant flow of ideas for utilizing them for the solution of various industrial problems. Methods involving radioactivity for their fundamental operation will be suggested by those familiar with industrial problems if they know the basic properties of radioactive isotopes and their associated radiation. It then becomes a problem of selecting a given radioisotope which best suits a proposed use.

Five criteria are set forth which apply generally to most of the types of application:

1. Determination of the most suitable half-life for the proposed use. Tracer work usually demands relatively short-lived, rapidly decaying isotopes, while applications depending upon the properties of radiation generally demand constant-strength sources, hence long half-life.
2. Necessity for high specific activity. Some isotopes are available only combined with large quantities of inert material and are useless when they are to be made into small high-strength sources or soft radiation from them is to be utilized.
3. The best type of radiation for a given application. Gamma rays and neutrons penetrate matter readily, while alpha, beta, and X rays are relatively rapidly absorbed. Ionization of gases is inversely proportional to penetrability.
4. Cost. Isotopes are presently available at prices per millicurie of activity ranging from a few cents to many thousands of dollars. These prices are related to the means of production and chemical purification, and in general the cheapest isotopes are those fragments resulting from fission of uranium.
5. Safety. The isotope selected for a given application should be one presenting a minimum health hazard, not only from the point of view of radiation, but also because of the danger of indiscriminate contamination of wide areas. Beta and X-ray emitters offer the least radiation danger because of their low penetrability, and are to be preferred for all applications which permit their use.

The Atomic Energy Commission Isotopes Catalog forms a most useful source of data for the selection of radioisotopes according to these criteria.

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* Research carried out at Brookhaven National Laboratory under the auspices of the Atomic Energy Commission.

INSTITUTE ACTIVITIES

1950 Winter General Meeting to Have Largest Program in Institute History

The AIEE Winter General Meeting to be held at the Hotel Statler in New York, N. Y., January 30–February 3, 1950, will feature a broad program of professional and social activities. The technical program, by far the largest in the history of the Institute, is a result of the effort of the 39 technical committees in the five technical groups of the Institute. A group of inspection trips also has been arranged closely allied with the subject matter of the technical program.

During the meeting, both the Edison Medal and the Hoover Medal will be presented. The Edison Medal was awarded to Dr. K. B. McEachron and details of the award appear on page 80 of this issue. The Hoover Medal, which was awarded to Dr. Frank B. Jewett just prior to his death on November 18, 1949, will be presented posthumously. An announcement of this award appears on page 80 of this issue.

On the social side, there will be a dinner-dance, a smoker, theater tickets for out-of-town members, and special entertainment for the ladies.

TECHNICAL PROGRAM

The technical program and the committee meetings will be held in the Hotel Statler. The subjects of the various sessions and the tentative titles and authors of the papers to be presented at them will be found in the following.

Sessions pertaining to communications will cover telephone and telegraph transmission systems; telephone switching; mobile radio, which will include a paper on the pulse time modulation telemetering systems for rocket application; microwave communication and control systems; television broadcasting facilities; and one on facsimile. The conference on facsimile promises to be one of the most significant on the subject in recent years. It is expected that recently declassified military material will be presented and that the telegraph company will describe its simplified system of handling telegrams in facsimile employing nonoptical scanning.

The Science and Electronics Group has arranged for sessions or symposiums covering the following subjects: computing devices; nucleonic instruments; magnetic amplifiers; high-frequency measurements; electrical properties of gases; electrostatic processes; instruments and measurements; dielectrics; new devices, applications, and techniques; new types of vacuum tubes; gas conduction electron tubes; and magnetics. Two sessions will be devoted to gas conduction tubes; the first will cover basic problems of gas clean-up and deionization in thyratrons and the second session will deal with the design, application, and performance of tubes. In session 1 the basic problems of gas clean-up in an arc discharge will be discussed; a report will be presented on the study of the statistical nature and physical concept of thyratron deionization time; a paper will be presented describing a pulse test method for deionization time measurement, and another will discuss the application factors involved.

The symposium on magnetics will be divided into four sections: magnetostriction, which will include its measurement, single crystals of iron-silicon, and permanent magnets and other materials; commercial magnetic materials, including recent developments in commercially available magnetic materials and the properties of electrical sheets for rotating machinery; magnetic anisotropy, including growing oriented crystals and their magnetic properties, materials for magnetic amplifiers, and magnetic anisotropy in single crystals of Fe-Co alloys; and miscellaneous, covering the recording fluxmeter and magnetic powders.

Sessions on general applications will cover these subjects: long tube fluorescent lighting; land transportation; and instruments for testing insulating oils.

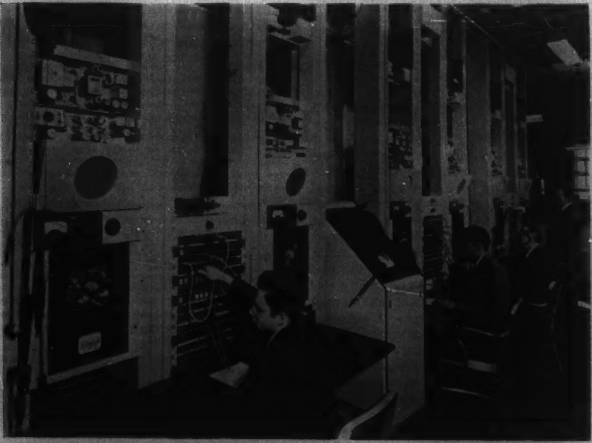
The Industry Group's sessions will cover electric heating; industrial control and feedback control systems; electric welding; electric batteries; cable insulation for chemical plants; chemical, electrochemical, and electrothermal applications.

The Power Group has arranged for sessions covering centralized station control; excitation systems; switchgear; power generation; operation of power systems at leading power factor; audible noise investigation in transformers; induction motors and d-c apparatus; synchronous motors; transformers and protective devices; instrument transformers.

A session will be sponsored by the Committee on Education describing the current program of the Engineers' Council for Professional Development Committee on Professional Training. This is a project designed to provide a guide for local sections and engineering councils in the formulation of programs for continued education, training, and social integration of the young engineer. Five speakers will cover the broad area of professional growth of the young engineer during that period when he bridges the gap between college and career. The joint responsibility of the colleges, the engineering societies, and of industry will be discussed. Other general sessions will cover statistical analysis as applied to electrical engineering problems; and safety activities of the AIEE, covering installations in hazardous locations.

INSPECTION TRIPS

An interesting and varied program of inspection trips has been arranged for those attending the Winter General Meeting. Since the number who may be accommodated on most of the trips is limited, members are urged to make arrangements for the trips they wish to take immediately upon registering at meeting headquarters. Advance



Three monitoring positions in the new television network control center at the headquarters building of the Long Lines Department of the American Telephone and Telegraph Company, to be inspected during the 1950 Winter General Meeting in New York, N. Y. Video and sound equipment at each position give technicians finger-tip control in testing, maintaining, and switching the network channels which interconnect local Manhattan studios with Bell System's intercity television networks

Future AIEE Meetings

Winter General Meeting
Hotel Statler, New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—closed*)

AIEE Conference on Electric Welding
Detroit, Mich.
April 5–7, 1950

AIEE Textile Conference
Georgia Institute of Technology
Atlanta, Ga.
April 13–14, 1950

AIEE Power Conference (Power Generation and Power Supply for Industrial Plants)
Hotel William Penn, Pittsburgh, Pa.
April 19–20, 1950

AIEE Conference on Electrical Engineering Problems in the Rubber and Plastics Industry
Akron, Ohio
April 1950

North Eastern District Meeting
Sheraton Biltmore Hotel, Providence, R. I.
April 26–28, 1950
(*Final date for submitting papers—January 26*)

AIEE Conference on Improved Electronic Components and Assemblies
Washington, D. C.
May 8–10, 1950

Great Lakes District Meeting
Hotel Hayes, Jackson, Mich.
May 11–12, 1950
(*Final date for submitting papers—February 10*)

Summer and Pacific General Meeting
Huntington Hotel, Pasadena, Calif.
June 12–16, 1950
(*Final date for submitting papers—March 14*)

Middle Eastern District Meeting
Lord Baltimore Hotel, Baltimore, Md.
October 3–5, 1950
(*Final date for submitting papers—July 5*)

Fall General Meeting
Skirvin Hotel, Oklahoma City, Okla.
October 23–27, 1950
(*Final date for submitting papers—July 25*)

1951 Winter General Meeting
New York, N. Y.
January 22–26, 1951
(*Final date for submitting papers—October 31*)

Vacuum tube in production at the Evans Signal Laboratory, one of the United States Signal Corps Laboratories at Fort Monmouth, N. J., which is scheduled for inspection during the Winter General Meeting

registrations by mail cannot be accepted.

Radio City Music Hall (Tuesday morning, January 31). The Music Hall is one of the outstanding attractions of Rockefeller Center and is the home of the Rockettes, famous precision dancers. The trip will include a guided tour backstage to see the extensive electric and mechanical equipment and controls required to operate this huge theater. Part of the 5,500 horsepower of motor load are the two 250-horsepower motors for raising and lowering the 3-section stage and orchestra pit. The connected lighting load totals 3,500 kw.

Sewaren Generating Station (Tuesday afternoon, January 31). This entirely new 4-unit 450,000-kw plant under construction by Public Service Electric and Gas Company has three units now in operation. Efficient operation is assured by throttle steam conditions of 1,500 pounds per square inch and 1,050 degrees Fahrenheit and eight stages of feedwater heating. Building volume and cost are reduced by semioutdoor-type boilers.

The station is built on the unit design principle with each unit independent of the others. Station power for auxiliaries is furnished by shaft-end generators with automatic throwover to a supply from the system. Complete mechanical and electrical control of the 4-unit station is centered in two control rooms, one for each pair of units. Unusual features of the station include the use of Oilostatic generator leads with forced cooling, aluminum bus for the 13-kv and 132-kv outdoor busses, and extended use of the tray system for station power cables.

The inspection trip will highlight features of interest to AIEE members.

American Telephone and Telegraph Company, Long Distance Headquarters (Tuesday afternoon, January 31). The world's largest long-distance center is housed in a 28-story structure which, with its amazing contents, represents an investment of more than 72 million dollars. AIEE members will see the large operating rooms where the switchboard would extend for more than a mile if placed side-by-side. Half a million calls are handled daily by the more than 4,000 long distance operators employed there.

Typing-by-wire, or TWX Service, will be explained on location. The new Overseas Operating Room is the telephone crossroads of the world. Eighty-five countries are within easy reach of the overseas operators, by radio telephone.

AIEE groups also will be taken backstage into the Overseas Control Room and the Audio and Video Network Center to the Bell System's New York Television Network Center. The Coaxial Cable Terminal Room and the Microwave Radio Relay Equipment on the roof of the building will be seen also.

Standard Oil Company of New Jersey, Bayway Esso Refinery and Research Center (Wednesday afternoon, February 1). The Esso Bayway Refinery is one of the world's largest, taking crude oil and converting it into gasoline, kerosene, diesel oil, fuel oils, lubricating distillate, and a whole series of chemicals and specialty products. There are many tremendous units—pipe stills, polymerization units, and both thermal and fluid catalytic cracking units. The newest "Cat" cracker, just recently installed, is the largest in the world.

The Esso Research Center provides modern air-conditioned working facilities for 600 persons engaged in the development of the fuels and lubricants of the future, rubber-like materials, resins, and plastics.

The New York Herald Tribune (Wednesday evening, February 1). One of America's great daily newspapers, the New York *Herald Tribune* is produced in a modern 20-story publishing plant. In this plant visitors will see its many departments, including the Home Institute testing kitchens, reader service, advertising, promotion, financial, editorial, picture department, editorial-art, city newsroom, foreign desk, wire-service room, the linotype machines, press room, and mailing machines.

United States Signal Corps Engineering Laboratories at Fort Monmouth, N. J. (Thursday, all day, February 2). This is the home of the Signal Corps and one of the greatest military training and technological centers of its kind in the world. Research and development operations are carried on in three closely integrated laboratories known as Squier, Coles, and Evans Signal Laboratories. These technical activities embrace all phases of electronics, photography, and meteorology, including the research, design, and improvement of radio and communications television equipments, facsimile, nucleonic devices, radar, and other fields. Concurrent research proceeds in components, batteries, vacuum tubes, resistors, capacitors, transformers, coils, and cables. Approximately

(*Continued on page 77*)

Tentative Technical Program

Winter General Meeting, New York, N. Y., January 30–February 3

Monday, January 30

10:00 a.m. Transformers

50-8. Audible Noise of Power Transformers. *T. D. Gordy*, General Electric Company

50-18. Harmonic Index—A Tool for Transformer Audio Noise Investigation. *W. H. Mutschler, Jr., T. F. Madden*, Allis-Chalmers Manufacturing Company

50-19. Audio Noise in Transformers in Residential and Commercial Areas. *C. E. Baugh*, Pacific Gas and Electric Company

CP. Transformer Sound Level Considerations.** *A. J. Maslin*, Westinghouse Electric Corporation

CP. Quiet Transformer Installation, a Problem for Both Equipment and Substation Designers.** *I. S. Mendenhall, F. L. Taylor*, The Detroit Edison Company

10:00 a.m. Rotating Machinery

50-1. Suggested Improvements in the Performance Calculations of Single-Phase Induction Motors. *M. S. Thacker, H. V. Gopalakrishna*, Indian Institute of Science

50-20. Generator Rating of Induction Motors. *Otto J. M. Smith*, University of California

50-21. Quick and Accurate Production Testing on Large D-C Apparatus. *M. J. Baldwin, H. D. Barnhart*, General Electric Company

50-22. Transient Response of D-C Dynamos. *H. E. Koenig*, University of Illinois

50-23. Maximum Short-Circuit Current of D-C Motors and Generators. *Subcommittee on D-C Machinery.* Prepared by *A. G. Darling*

10:00 a.m. New Electronic Devices, Applications and Techniques

CP. Magnetic Modulation of Photo-currents and Its Application.** *H. P. Kalmus*, National Bureau of Standards

CP. Magnetic Current Regulator.** *C. A. Black, H. A. Gauper*, General Electric Company

CP. Manufacture of Electron Tube Parts by the Rubber-Die Technique.** *W. J. Bachman*, Radio Corporation of America

CP. Optical Contour Follower Control for Machine Tools.** *T. M. Berry*, General Electric Company

10:00 a.m. Electric Heating

10:00 a.m. Industrial Control and Feedback-Control Systems

50-24. Characteristics of Some Magnetic-Fluid Clutch Servomechanisms. *A. J. Porziale*, Massachusetts Institute of Technology; *P. D. Tilton*, Vickers Electric Division

CP. Speed of Response of Saturable Reactors.** *H. F. Storm*, General Electric Company

50-25–ACO.* An Electronic Synchronous Speed Regulator. *William J. M. Moore*, National Research Council

CP. Standard Nomenclature for Feedback-Control Systems.** *Subcommittee on Nomenclature*

10:00 a.m. Developments in Long Tube Fluorescent Lighting

CP. Long Tube Lamp Trends.** Sylvania Electric Products

CP. Ballast Developments for Long Tube Lamps.** General Electric Company

CP. Fixture Design as Affected by Long Tube Lamps.** *H. P. Steele*, Benjamin Electric Manufacturing Company

CP. The Application and Installation of the Long Tube Lamp.** *B. F. Greene*, New York, N. Y.

2:30 p.m. General Session

Tuesday, January 31

9:30 [illegible] Transformers and Protective Devices

CP. Control Transformers.** *J. M. Frank, A. J. Hauck*, Hevi Duty Electric Company

50-17. Margins Between Arrester Protective Levels and Transformer Insulation. *F. J. Vogel*, Illinois Institute of Technology

50-14. Lightning Arresters as a Criterion for Insulation Levels. *H. L. Rorden*, Bonneville Power Administration

50-26. Application and Handling of Very Large Power Transformers on the System of the Bonneville Power Administration. *Richard F. Stevens*, Bonneville Power Administration

50-99–ACO.* Proposed Changes in Methods in Making Temperature Rise Tests on Transformers. *Committee on Transformers*

9:30 a.m. Rotating Machinery

50-27–ACO.* Lightweight Turbine Generator Rotors. *Th. de Koning*, Philadelphia, Pa.

50-28. Liquid Cooling of A-C Turbine Generators. II. *Carl J. Fechheimer*, Milwaukee, Wis.

50-29. Surface Heat-Transfer Coefficients for Hydrogen-Cooled Rotating Electric Machines. *D. S. Snell, R. H. Norris, Mrs. B. O. Buckland*, General Electric Company

50-30. Loading of Hydrogen-Cooled Generators at Elevated Gas Pressures. *D. S. Snell*, General Electric Company

9:30 a.m. Telephone and Telegraph Transmission Systems

50-10. A 2-Channel Carrier Telegraph System for Short Submarine Cables. *E. L. Newell, C. H. Cramer*, Western Union Telegraph Company

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—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

50-6. A New Electronic Telegraph Regenerative Repeater. *B. Ostendorf, Jr.*, Bell Telephone Laboratories, Inc.

50-101-ACO.* Magnetic Cores of Thin Tape Insulated by Cataphoresis. *H. L. B. Gould*, Bell Telephone Laboratories, Inc.

CP. Compandors for Telephone Circuits.** *P. G. Edwards*, Bell Telephone Laboratories, Inc.

50-13. A Printing Telegraph Tape-to-Page Translator. *A. E. Frost*, The Western Union Telegraph Company. Presentation by title only

9:30 a.m. Electrostatic Processes I

CP. Limitations of Conductance Electrostatic Separators.** *G. W. Penney*, Carnegie Institute of Technology; *G. W. Hewitt*, Westinghouse Electric Corporation

CP. A Discussion of Methods for the Measurement of Space Charge Density.** *W. B. Dodson*, American Air Filter Company

CP. Electrical Charging of Dielectric Films Used in Xerography.** *C. D. Oughton, J. J. Rheinfrank, J. P. Ebert*, Battelle Memorial Institute

9:30 a.m. Large Electronic D-C Motor Drives

50-31–ACO.* Large Electronic D-C Motor Drives in Industry. *M. M. Morack*, General Electric Company

50-32. Control of Large D-C Motors Supplied From Ignitron Rectifiers. *O. W. Livingston*, General Electric Company

50-33. Rectifier Equipment for Electronic D-C Motor Drives. *M. J. Mulhern, S. N. Crawford*, General Electric Company

50-34. Application of Electronic Motor Drives to Printing Presses. *J. A. Johnson*, Times-Mirror Company; *E. M. Stacey*, General Electric Company

9:30 a.m. Computing Devices

50-15. Analogue Computer for Multicomponent Fractionation Calculations. *G. W. Goelz, J. F. Calvert*, Northwestern University

50-47. An Electronic Simulator for Nonlinear Servomechanisms. *Charles M. Edwards, E. Calvin Johnson, Jr.*, Massachusetts Institute of Technology

50-48. A Generalized Analogue Computer for Flight Simulation. *Albert C. Hall*, Massachusetts Institute of Technology

CP. Technique of Handling Power System Problems on a Modern A-C Network Calculator.** *P. O. Bobo*, Westinghouse Electric Corporation

50-85. New Techniques on the Anacom. *E. L. Harder, J. T. Carleton*, Westinghouse Electric Corporation

2:00 p.m. Sections Committee

2:00 p.m. Centralized Station Control

CP. Centralized Station Control.** *J. M. Drabelle* Iowa Electric Light and Power Company

50-91. Centralized Instrumentation and Controls for Steam Electric Power Stations. *B. C. Mallory*, Stone and Webster Engineering Corporation

50-92. Design and Operation of Central Control Rooms. *B. F. Borgel*, Pennsylvania Electric Company

CP. Centralized Control Desirable for Single Boiler-Turbine-Generator Units.** *J. A. Lind, J. M. Geiger*, Buffalo Niagara Electric Corporation

2:00 p.m. Rotating Machinery

50-36. Spring and Damping Coefficients of Synchronous Machines and Their Application. *L. A. Kilgore, E. C. Whitney*, Westinghouse Electric Corporation

50-37-ACO.* Analysis of Synchronous Machine Short Circuits. *Robert D. Camburn*, Commonwealth and Southern Corporation; *Eric T. B. Gross*, Illinois Institute of Technology

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*ACO: Advance copies only available; not intended for publication in *Transactions*.

**CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

50-38. Per Unit Inductance of Synchronous Machines. *H. S. Kirschbaum*, Ohio State University

50-39. Potier Reactance for Salient-Pole Synchronous Machines. Saad L. Mikhail, Cambridge, Mass.

CP. Design Calculations for A-C Generators.** *David Ginsberg*, United States Engineer Research and Development Laboratories

2:00 p.m. Telephone Switching

50-40. Basic Theory Underlying Bell System Facilities Capacity Tables. *A. L. Gracey*, American Telephone and Telegraph Company

50-41. The Number 5 Crossbar Dial Telephone Switching System. *F. A. Korn*, *James G. Ferguson*, Bell Telephone Laboratories, Inc.

50-42. Fundamentals of the Automatic Telephone Message Accounting System. *John Meszar*, Bell Telephone Laboratories, Inc.

2:00 p.m. Symposium on Magnetics

CP. Magnetostriction and Its Measurement.** *J. E. Goldman*, Westinghouse Electric Corporation

CP. Magnetostriction of Single Crystals of Iron-Silicon.** *W. J. Carr*, Westinghouse Electric Corporation

CP. Magnetostriction of Permanent Magnets and Other Materials.** *E. A. Nesbitt*, Bell Telephone Laboratories, Inc.

CP. Recent Developments in Commercially Available Magnetic Materials.** *L. C. Hicks*, Allegheny Ludlum Steel Corporation

CP. The Properties of Electrical Sheet for Rotating Machinery.** *H. F. Shannon*, Carnegie-Illinois Steel Company

2:00 p.m. Electrostatic Processes II

CP. Suggested Standards for Electric Power Supplies Used in Electrostatic Precipitation.** *W. D. Cockrell*, *H. V. Nelson*, General Electric Company

CP. Electrical Precipitators for De-tarring Manufactured Gas.** *A. N. Anderson*, Consolidated Edison Company of New York, Inc.

CP. Electrocoating Sandpaper and Textile Fabrics.** *J. O. Amstuz*, Behr-Manning Corporation

2:00 p.m. Feedback-Control Systems

50-43–ACO.* An Air-borne Synchronized Motion Picture Camera Recording System. *Viola J. White*, *Sidney J. Horwitz*, Northwestern University

50-44. A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms. *R. J. Kochenburger*, Massachusetts Institute of Technology

50-45. Phase Lead for A-C Servo Systems With Compensation for Carrier Frequency Changes. *A. P. Notthoff, Jr.*, Massachusetts Institute of Technology

50-11. Control System Synthesis by Root Locus Method. *W. R. Evans*, North American Aviation, Inc.

50-46. Improvements in the Characteristics of A-C Lead Networks for Servomechanisms. *D. McDonald*, University of Michigan. Presentation by title only

Wednesday, February 1

9:30 a.m. Excitation Systems

50-49. Excitation System Performance With Motor-Driven Exciters. *A. G. Mellor*, *M. Temoshok*, General Electric Company

50-50. Design and Test on Electronic Exciter Supplied From Common Shaft-Driven Generator. *A. P. Colaiaco*, *A. A. Johnson*, *J. E. Reilly*, Westinghouse Electric Corporation

50-51. Excitation Improvement. *A. H. Phillips*, Gilbert Associates, Inc.; *W. H. Lambert*, *D. R. Pattison*, Pennsylvania Electric Company

9:30 a.m. Insulated Conductors

50-52. The Thermal Resistance Between Cables and a Surrounding Pipe or Duct Wall. *F. H. Buller*, *J. H. Neher*, Philadelphia Electric Company

50-53. Development of Improved Luminous Sign Cable. *L. F. Roehmann*, *E. W. Greenfield*, Anaconda Wire and Cable Company

50-54–ACO.* Terminals and Joints for Insulated Power Cables, Electrical Design Considerations. *L. F. Roehmann*, Anaconda Wire and Cable Company

50-55. Heat Transfer Study on Power Cable Ducts and Duct Assemblies. *Paul Greebler*, Johns-Manville; *Guy F. Barnett*, Philco Radio and Television Corporation

9:30 a.m. Mobile Radio

CP. Design of Communication Equipment for Maximum Channel Utilization.** *L. P. Morris*, Galvin Manufacturing Corporation

CP. Allocation of Frequencies for Railroad Use.** *L. W. Kearney*

CP. Pulse Time Modulation Telemetering Systems for Rocket Application.** *J. T. Mengel*, Naval Research Laboratory

9:30 a.m. Symposium on Magnetics

CP. Growing Oriented Crystals and Their Magnetic Properties.** *W. Morrill*, General Electric Company

CP. Magnetic Anisotropy in Single Crystals of Fe-Co Alloys.** *H. J. Williams*, Bell Telephone Company

CP. Recording Fluxmeter.** *P. P. Cioffi*, Bell Telephone Laboratories, Inc.

CP. Magnetic Powders.** *C. C. Neighbors*, Consulting Engineer

9:30 a.m. Nucleonic Instruments

CP. Pulse Amplitude Discriminators.** *H. G. Weiss*, Raytheon Manufacturing Company

CP. The Brookhaven Cosmotron.** *M. G. White*, *G. K. Green*, *J. P. Blewett*, Brookhaven National Laboratories

CP. Nuclear Pulses and Their Amplification.** *H. E. DeBolt*, Westinghouse Electric Corporation

CP. Equipment for Uranium Prospecting.** *Frank Stead*, United States Department of the Interior

CP. The Control Problems of a Power Producing Nuclear Reactor.** *J. M. Harrer*, Argonne National Laboratories

9:30 a.m. Gas Conduction Electron Tubes

CP. Clean-up of a Noble Gas in an Arc Discharge.** *M. J. Reddan*, United States Bureau of Standards

50-56. Statistical Nature and Physical Concepts of Thyratron Deionization Time. *H. A. Romanowitz*, University of Kentucky; *W. G. Dow*, University of Michigan

CP. Pulse Test Method for Deionization Time Measurement.** *H. H. Wittenberg*, Radio Corporation of America

CP. Commutation Factor Rating of Inert Gas Thyratrons and Its Influence on Circuit Design.** *D. E. Marshall*, *C. L. Shackelford*, Westinghouse Electric Corporation

9:30 a.m. Electric Welding

CP. Electronically Controlled Head for Electrode Testing.** *Bela Ronay*, United States Naval Engineering Experiment Station

CP. Preheating and Stress Relieving.** *E. H. Wilhelm*, United States Naval Engineering Experiment Station

CP. Stud Welding.** *R. C. Singleton*, Morton-Gregory Corporation

9:30 a.m. Conference on Education

CP. The Continued Education of the Engineer in Industry.** *J. C. McKeon*, Westinghouse Electric Corporation

CP. Orientation and Training of the Young Engineer in Industry.** *Guy Klies*, Westinghouse Electric Corporation; *J. S. Crout*, Battelle Memorial Institute

CP. Professional Registration of the Young Engineer.** *H. L. Solberg*, Purdue University

CP. Self-Appraisal Methods for Valuable Characteristics in Engineering.** *A. R. Cullimore*, Newark College of Engineering

CP. Integrating the Young Engineer Into His Community.** *K. B. McEachron*, General Electric Company

2:00 p.m. Power Generation

50-57. Effect of Buck-Boost Voltage Regulator on Steady State Power Limit. *Charles Concordia*, General Electric Company

50-58. Regulation of A-C Generators With Suddenly Applied Loads—II. *E. L. Harder*, *R. C. Cheek*, *J. M. Clayton*, Westinghouse Electric Corporation

50-59. Bus Transfer Tests on 2,300-Volt Station Auxiliary System. *A. A. Johnson*, Westinghouse Electric Corporation; *H. A. Thompson*, Duquesne Light Company

2:00 p.m. Switchgear

50-4–ACO.* Outdoor Metal-Clad Switchgear. *P. R. Pierson*, Westinghouse Electric Corporation

50-60. A New Grounding and Testing Device for Metal-Clad Switchgear. *H. Krida*, *E. T. McCurry*, General Electric Company

50-12. High-Voltage Oil Circuit Breakers for 5,000,000 to 10,000,000 Kva Interrupting Capacity. *W. M. Leeds*, *R. E. Friedrich*, Westinghouse Electric Corporation

50-3. Development and Testing of an Improved High-Voltage High-Capacity Impulse Circuit Breaker. *E. B. Rietz*, General Electric Company. Presentation by title only

50-61. A New 69-Kv Oil-Blast Circuit Breaker. *E. B. Rietz*, *C. J. Balentine*, General Electric Company. Presentation by title only

2:00 p.m. Microwave Communication and Control Systems

CP. The Keystone Pipe Line PTM Microwave Link.** *E. B. Dunn*, Keystone Pipe Line Company; *A. J. Finocchi*, Federal Telecommunication Laboratories, Inc.

CP. Power Line Fault Locator Utilizing Pulse Time Modulation Radio Relays.** *R. W. Hughes*, *Nelson Weintraub*, Federal Telecommunication Laboratories, Inc.

CP. Radio Links for Television.** *E. M. Ostlund*, Federal Telecommunication Laboratories, Inc.

2:00 p.m. The Electrical Properties of Gases

CP. Gaseous Conduction Phenomena and Their Application in Electrical Engineering.** *J. D. Cobine*, General Electric Company

CP. Mechanism of the Spark Breakdown.** *L. H. Fisher*, New York University

CP. Fundamental Processes in Gaseous Tube Rectifiers.** *A. W. Hull*, General Electric Company

CP. Microwave Gas Discharges.** *M. A. Biondi*, Westinghouse Electric Corporation

2:00 p.m. Instrument Transformers

50-62. Orthomagnetic Bushing Current Transformer *J. W. Farr*, General Electric Company

50-63. A Survey of Bushing-Type Current Transformers for Metering Purposes. *G. Camilli*, General Electric Company

50-64. The Theory of the Current Transductor and Its Application in the Aluminum Industry. *T. R. Specht*, Westinghouse Electric Corporation; *R. N. Wagner*, Aluminum Company of America

50-65. Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases. *Working Group of the Subcommittee on Instrument Transformers*

50-66. A New Dry-Type Insulation for Instrument Transformers. *R. A. Pfuntner*, *R. E. Franck*, *F. R. D'Entremont*, General Electric Company

50-67–ACO.* A Primary Method of Measuring the Ratio and Phase Angle of Current Transformers. *A. L. Brownlee*, Commonwealth Edison Company

2:00 p.m. Magnetic Amplifiers

50-76. An Analysis of Transients in Magnetic Amplifiers. *D. W. VerPlanck*, *L. A. Finzi*, *D. C. Beaumariage*, Carnegie Institute of Technology. Presentation by title only

50-94. An Analysis of Transients and Feedback in Magnetic Amplifiers. *W. C. Johnson*, Princeton University; *F. W. Latson*, Kellex Corporation

50-93–ACO.* Magnetic Amplifiers of the Balance Detector Type—Their Basic Principles, Characteristics, and Applications. *W. A. Geyger*, United States Naval Ordnance Laboratory

50-95. A Magnetic Amplifier Frequency Control. *L. J. Johnson, H. G. Schafer*, Naval Research Laboratory

2:00 p.m. Electric Welding

CP. Unionmelt Automatic Welding Control.** *J. A. Kratz*, The Linde Air Products Company

CP. Submerged Arc Welding Control.** *L. K. Stringham*, The Lincoln Electric Company

CP. Power Saving Controls.** *F. H. Varney*, D-V Welding Controls

2:00 p.m. Industrial Control

CP. Control Sequence of D-C Adjustable-Voltage Drives.** *E. E. Moyer*, Rensselaer Polytechnic Institute; *M. E. Cummings*, Bell Telephone Company

CP. The Operating Time of D-C Magnet Brakes.** *J. E. Ryan*, General Electric Company

CP. Basis of Rating a Plate Rheostat.** *L. J. Parkinson*, General Electric Company

CP. Practical Design of Industrial Regulating Systems.** *S. L. Burgwin*, Westinghouse Electric Corporation

Thursday, February 2

9:30 a.m. Transmission and Distribution

50-96. Dielectric-Recovery Characteristics for Power Arcs in Large Air Gaps. *G. D. McCann, J. E. Conner, H. M. Ellis*, California Institute of Technology

50-97. Total and Incremental Losses in Power Transmission Networks. *J. B. Ward, J. R. Eaton, H. W. Hale*, Purdue University

50-98. A Voltage Gradient Meter. *R. L. Tremaine, R. C. Cheek*, Westinghouse Electric Corporation

9:30 a.m. Symposium on Relays

50-7. Combined Phase and Ground Distance Relaying. *W. C. New*, General Electric Company

50-16. Consideration of Requirements and Limitations of Relaying and High-Speed Reclosing on Long and Heavily Loaded Transmission Lines. *C. E. Parks*, Public Service Company of Indiana, Inc.; *W. R. Brownlee*, Commonwealth and Southern Corporation

50-68. Relay Protection for Medium-Length High-Voltage Transmission Lines. *J. H. Kinghorn*, American Gas and Electric Service Corporation

50-69. Transmission Line Protection of Short Lines of the Metropolitan Area of a Typical System. *W. E. Marter*, Duquesne Light Company

50-70. Sensitive Ground Protection. *Project Committee of Relay Committee*

9:30 a.m. Broadcasting Facilities

CP. A 5-Kw Iron Core Coupled Radio Transmitter.** *L. F. Deise, L. W. Gregory*, Westinghouse Electric Corporation

50-71–ACO.* The Application of Germanium Diodes in High- and Ultrahigh-Frequency Television Receivers. *J. H. Sweeney*, General Electric Company

CP. WOR-TV Television Station Construction Problems.** *Charles Singer*, Radio Station *WOR-TV*

CP. A Cathode-Ray Sweep Transformer With Ceramic Iron Core.** *C. E. Torsch*, General Electric Company

50-72. Clampers in Video Transmission. *S. Doba, Jr., J. W. Rieke*, Bell Telephone Laboratories, Inc. Presentation by title only

9:30 a.m. Electric Batteries

CP. Primary Cells.** *Charles Clarke*, Signal Corps Engineering Laboratories

CP. Storage Cells.** *Hyman Mandell*, Signal Corps Engineering Laboratories

CP. One-Shot Batteries.** *Adolph Fishbach*, Signal Corps Engineering Laboratories

9:30 a.m. Instruments and Measurements

CP. Equipment for Instrument Calibration.** *E. A. Gilbert*, Radio Frequency Laboratories, Inc.

50-73. Noncontacting Thickness Gauge Using Beta Rays. *C. W. Clapp, S. Bernstein*, General Electric Company

50-74. An Improved Method of Measuring Dissipation Factor and Dielectric Constant Using the Susceptance Variation Principle. *C. F. Miller*, The Johns Hopkins University; *F. G. Whelan*, Association of American Railroads

50-75–ACO.* Three-Phase Measurements of Resistance. *L. W. Matsch, N. C. Basu*, Illinois Institute of Technology; *G. R. Horcher*, University of Kansas

CP. Power Measurement by the Hook-on Method.** *A. J. Corson, A. L. Nylander*, General Electric Company

50-89. Impulse Measurements by Repeated-Structure Networks. *C. L. Dawes, C. H. Thomas*, Harvard University; *A. B. Drought*, Marquette University. Presentation by title only

50-90. The Irradiation of Spark Gaps for Voltage Measurement. *D. R. Hardy, J. D. Craggs*, The University of Liverpool. Presentation by title only

9:30 a.m. Electron Tubes

CP. Microphonism Investigation.** *Lester Feinstein*, Sylvania Electric Products, Inc.

CP. The Use of Conductance Curves for Pentode Circuit Designs.** *A. H. Hodge, K. A. Pullen*, Aberdeen Proving Ground

CP. Arc Drop of Hot Cathode Gas Tubes in Service—Measurement Methods and Data.** *E. K. Smith*, Electrons, Inc.

CP. A Cold Cathode Counting or Stepping Tube.** *M. A. Townsend*, Bell Telephone Laboratories, Inc.

9:30 a.m. Land Transportation

50-77. The Alco-GE 4,500-Horsepower Gas-Turbine Electric Locomotive. *A. H. Morey*, General Electric Company

50-78. Control System for a 4,500-Horsepower Gas-Turbine Electric Locomotive. *T. J. Warrick*, General Electric Company

50-79. Rotating Electric Equipment for a Gas-Turbine Electric Locomotive. *O. C. Coho*, General Electric Company

9:30 a. m. General Industry Applications

CP. Explosion Hazards in Industry and Their Relation to Electrical Installations.** *K. Pinder*, E. I. du Pont de Nemours and Company

CP. Underwriters Laboratories Classification and Test of Electric Equipment for Hazardous Locations.** *A. F. Matson*, Underwriters Laboratories, Inc.

CP. Motor Selection for Hazardous Locations.** *J. Z. Linsenmeyer*, Westinghouse Electric Corporation

CP. Wiring Equipment and Methods for Hazardous Locations.** *O. H. Bissell*, Crouse-Hinds Company

50-9. Basic Patterns for Arrangement of Electric Power Systems for Steel Mills. *H. J. Finison*, Armour Research Foundation. Presentation by title only

2:00 p.m. Conference on Facsimile

CP. Radiophoto Practices and Problems.** *Russel Hammond*, RCA Communications, Inc.

CP. Facsimile Broadcasting.** *J. V. L. Hogan*, Hogan Laboratories

CP. An 1,800-Cycle Synchronous Motor.** *A. G. Cooley*, Times Facsimile Corporation

CP. Telegraph Office Desk-Fax Concentrator.** *A. W. Breyfogel, J. H. Hackenberg, F. G. Hallden*, The Western Union Telegraph Company

CP. Electronic Flat Scanning Facsimile Applications.** *W. G. H. Finch, C. R. Jones*, Finch Telecommunications, Inc.

2:00 p.m. Operation of Power Systems at Leading Power Factor

Conference papers and informal discussions covering the following subjects:

System Design Considerations Resulting in System Leading Power Factor

Generator Design Characteristics Determining Safe Power Factor Operating Limits

Review of Tests and Experiences of Power Systems Operating at Leading Power Factor

2:00 p.m. Statistical Analysis as Applied to Electrical Engineering Problems

2:00 p.m. High-Frequency Measurements

CP. Television Transient Analyzer.** *Joseph Fisher* Philco Corporation

CP. Television Impulse Interference Generator** *Jack Fogarty*, Philco Corporation

CP. A Versatile Microwave Measuring Equipment.** *S. C. Clark*, General Electric Company

50-80-ACO.* Automatic Calibration of Oscillator Scales. *W. J. Means, T. Slonczewski*, Bell Telephone Laboratories, Inc.

CP. Determination of Attenuation From Impedance Measurements.** *R. W. Beatty*, National Bureau of Standards

CP. Progress and Development of Crystal Unit Test Oscillators.** *L. F. Koerner*, Bell Telephone Laboratories, Inc.

2:00 p.m. Land Transportation

50-81. Rectifier-Type Motive Power for Railroad Electrifications. *L. J. Hibbard, C. C. Whittaker, E. W. Ames*, Westinghouse Electric Corporation

50-100. Solderless Commutator Joints for High-Temperature Operation of Railway Traction Armatures. *J. R. Reed*, National Electric Coil Company of Columbus, Ohio

(Presentation of this program will be followed by a meeting of the Committee on Land Transportation)

2:00 p.m. Safety Activities of the AIEE

CP. Electrical Hazards to Farm Stock Prepared for AIEE Safety Committee.** *W. B. Buchanan*, The Hydro-Electric Power Commission of Ontario

CP. Rural Neutral Potentials.** *J. H. Waghorne*, The Hydro-Electric Power Commission of Ontario

CP. Protective Grounding of Electrical Installations on Customer's Premises.** *A. H. Schirmer*, Bell Telephone Laboratories, Inc.

50-2. Electric Fences. *C. F. Dalziel*, University of California. Presentation by title only

Friday, February 3

9:30 a.m. Protective Devices

50-82. New Lightning Arrester Standard. *H. R. Stewart*, New England Power Service Company; *F. M. Defandorf*, National Bureau of Standards

50-83. Surge Protection of Cable Connected Equipment. *R. L. Witzke, T. J. Bliss*, Westinghouse Electric Corporation

CP. Power System Fault Control.** *F. R. Longley*, Western Massachusetts Electric Company
(A report by the Committee on Protective Devices.)

9:30 a.m. Symposium on Dielectrics

CP. Dielectrics in Electrical Engineering.** *A. von Hippel*, Massachusetts Institute of Technology

CP. Structure and Polarization of Atoms and Molecules.** *J. C. Slater*, Massachusetts Institute of Technology

CP. Relaxation Phenomena in Liquids and Solids.** *C. P. Smyth*, Princeton University

CP. Modern Plastics.** *H. Mark, T. Alfrey*, Polytechnic Institute of Brooklyn

9:30 a.m. Electronic Instruments

50-5. The Direct Measurement of Bandwidth *C. R. Ammerman*, The Pennsylvania State College

CP. An Electron Tube Characteristic Generator.** *M. L. Kuder*, National Bureau of Standards

CP. Thermal Feedback Circuit for Computation and RMS Measurement.** *R. D. Campbell*, Reed Research, Inc.

CP. A New Cathode-Ray Oscillograph for Impulse Testing.** *W. G. Fockler*, Allen B. DuMont Laboratories, Inc.

50-84. The Metrotype System of Digital Recording and Telemetering. *G. E. Foster*, Metrotype Corporation

9:30 a.m. Chemical, Electrochemical, and Electrothermal Applications

CP. Cable Insulation for Chemical Plants.** *L. F. Hickernell*, Anaconda Wire and Cable Company

CP. Cable Insulation for Chemical Plants.** *J. J. FitzGibbon*, General Electric Company

CP. Cable Insulation for Chemical Plants.** *R. C. Graham*, Rome Cable Corporation

CP. Cable Insulation for Chemical Plants.** *E. W. Davis*, Simplex Wire and Cable Company

9:30 a.m. Domestic and Commercial Applications

CP. A Critical Examination of Heat Sources and Sinks for Heat Pumps.** *Professor Charles H. Coogan*, University of Connecticut

CP. Research in Heat Pump Systems.** *Professor G. H. Hickox*, University of Tennessee

CP. Heat Pump Design.** *T. C. Johnson*, General Electric Company, Bloomfield, N. J.

CP. Radiant Panel Heating.** *R. C. Cassidy*, United States Rubber Company, New York, N. Y.

CP. Radiant Electric Heating.** *L. N. Roberson*, Seattle, Wash.

2:00 p.m. Symposium on Dielectrics

CP. Conduction Phenomena in Gases.** *J. P. Molnar*, Bell Telephone Laboratories, Inc.

CP. Conduction in Liquids and Plastics.** *R. M. Fuoss*, Yale University

CP. Fluorescence and Phosphorescence.** *P. Pringsheim*, Atomic Energy Commission

2:00 p.m. Symposium on Instruments for Testing Insulating Oils, Oil Conditions in the Field, and the Effects of Remedial Measures

2:00 p.m. Chemical, Electrochemical, and Electrothermal Applications

50-86. Design and Control of Ferro Alloy Furnaces. *F. V. Andreae*, Southern Ferro Alloys Company. Presentation by title only

50-87. Electric Equipment and Operation of Graphitizing Furnaces. *E. R. Cole*, The Dow Chemical Company. Presentation by title only

50-88. Electrode Control and Associated Operating Mechanisms. *E. A. Hanff*, Swindell-Dressler Corporation. Presentation by title only

CP. Cable Insulation for Chemical Plants.** *H. E. Houck*, E. I. duPont de Nemours and Company

CP. Cable Insulation for Chemical Plants.** *F. S. Glaza*, Dow Chemical Company

CP. Cable Insulation for Chemical Plants.** *J. A. Horacek*, Diamond Alkali Company

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(*Continued from page 73*)

2,000 scientists and supporting personnel are employed in this vast research and development program.

The tour of these laboratories is restricted to United States citizens.

Cable Plant, Western Electric Company at Kearny, N. J. (Thursday afternoon, February 2). Products manufactured for the Bell System at this plant include lead sheath and alpeth-covered telephone cable. This is one of the largest cable plants in the country, and employs a number of unique processes, such as the application of pulp insulation by making paper directly on the wire, a stranding operation in which the spools of wire and take-up reel are on fixed axes and the twisting is done by a revolving flyer; vacuum drying of cable core where the heat is applied by passing a current through the conductors; and the manufacture of cable with an aluminum and polyethylene (alpeth) sheath as a final covering in place of the usual sheath of lead.

This tour is open only to United States citizens.

WOR-TV Television Transmitter (Thursday afternoon, February 2). Television Station *WOR-TV* is one of the newest and most modern of television stations. Its equipment includes a 5-kw General Electric television transmitter, a 10-kw General Electric frequency-modulation transmitter, with associated consoles and control and utility equipment. Also to be seen is the DuMont 3-channel video input, distribution, and switching equipment. This station has the largest and tallest television tower in the country, rising 1,050 feet above sea level.

WOR-TV Television Studio (Friday morning, February 3). Visitors to this recently completed television studio will see the two 4-camera studios with their associated control rooms and equipment. A feature is the unique master control installation. The facilities include two General Electric 16-millimeter synchrolite film projectors and two Rex Cole 35-millimeter projectors with associated equipment, film, and editorial rooms.

United States Lines S.S. America (Friday afternoon, February 3). The *S.S. America* is the largest liner ever built in the United States. Used during World War II as a troop carrier, she made her maiden voyage to Europe as a passenger liner on November 14 ,1946. She has a gross tonnage of 36,000 and has a service speed of 20 knots and a reserve speed of 23 knots. She is powered by two sets of triple expansion turbines developing 34,000 shaft horsepower at 128 rpm. Her evaporators can manufacture 120,000 gallons of fresh water per day.

In addition to public rooms and staterooms, visitors will see the loran and radar installations, fire control station, radio room, and engine room.

SMOKER

All arrangements are complete for the popular "smoker" which this year returns to Tuesday night, January 31, 1950, at the Hotel Commodore. Chairman A. J. Cooper advises that the evening will open with a cocktail hour at 5:30 p.m. in the West Ballroom with dinner and show to follow. Tables for ten persons will be available and price of the tickets will be $8 per person. Though every effort will be made to meet all demands for tickets, the physical limits of the room have made this difficult for several years past. Reservations should be addressed to the Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Reservations received after January 24 will not be honored. Checks should be made payable to "Special Account, Secretary AIEE."

DINNER–DANCE

At this year's meeting, members and guests again will enjoy the pleasure of a formal dinner–dance. It will be held in the Grand Ballroom of the Hotel Statler, Thursday evening, February 2, 1950. Dinner will be served at 7:00 p.m. followed by dancing. Tables for the dinner and dance will accommodate ten persons. The price for the tickets will be $11 per person.

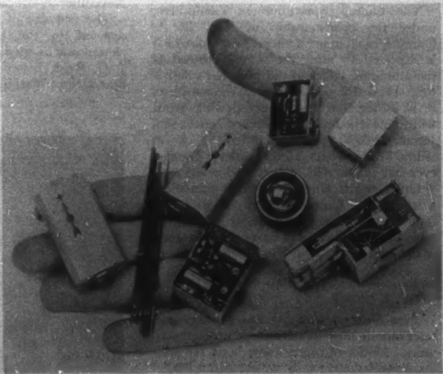
Reservations should be addressed to Dinner–Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Checks should be made payable to "Special Account, Secretary AIEE."

THEATER TICKETS

It is expected that tickets for the following shows will be available to out-of-town AIEE members during the week of the meeting. Prices are for orchestra seats, Monday, January 30, through Thursday, February 2, evenings.

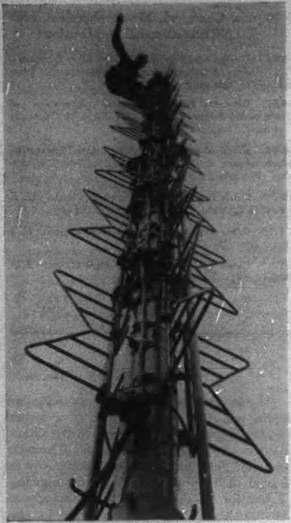
Death of a Salesman	$4.80
Kiss Me Kate	6.00
Mr. Roberts	4.80
Where's Charley	6.00

Enclose check in proper amount made



Examples of miniature batteries and communications circuits assembled by experimental techniques for study in military communications equipments. These may be seen during the Winter Meeting inspection trip to the United States Signal Corps Laboratories, Fort Monmouth, N. J.

Signal Corps Engineering Laboratories photo



Electrician making final adjustments on station WOR-TV's television antenna at North Bergen, N. J., is standing on the uppermost "bat-wing" which tops the 760-foot tower. The transmitter, which is situated on the Palisades overlooking Manhattan, will be visited during a Winter General Meeting inspection trip

payable to "American Institute of Electrical Engineers," with request for reservation and mail to Theater Ticket Committee, care of AIEE, 33 West 39th Street, New York 18, N. Y. Preference will be given to requests for even numbers of tickets. The right is reserved to reduce individual allotments to two seats, if demand exceeds supply for specific shows. In event of sellout, checks will be returned unless second choice of show or date is given and is available.

LADIES' ENTERTAINMENT

The Ladies' Entertainment Committee, under the chairmanship of Mrs. D. A. Quarles, is again arranging a program which is expected to meet the same approval of the attending ladies as did last year's activities. While the program is not yet complete, it is anticipated that the following items will be scheduled: Monday afternoon, January 30, "Get-Acquainted" Tea at ladies' headquarters, Hotel Statler; Tuesday evening, January 31, dinner and bridge.

Other events which are being planned are a trip to the United Nations, as well as a fashion show and luncheon for the out-of-town ladies. There will be a charge for most of the events.

HOTEL ACCOMMODATIONS

Members planning to attend the AIEE Winter General Meeting must make hotel reservations now to be sure of accommodations. Blocks of rooms have been set aside for a limited time only at the Hotel Statler (meeting headquarters) and nearby hotels.

Reservations must be made before January 20, 1950, and requests for reservations should be sent directly to the hotel of choice, but only to one hotel. A copy of the request should be sent to C. N. Metcalf, Vice-Chairman, Hotel Reservations Committee, care of the Consolidated Edison Company of New York, Inc., Room 1350-S, 4 Irving Place, New York 3, N. Y., and a second and third choice should be indicated thereon. If accommodations are not available at the hotel of first choice, the Hotel Reservations Committee will arrange for transfer of the request to one of the other meeting hotels.

Hotel rooms have been reserved at:

Hotel Statler (formerly Pennsylvania) Meeting headquarters, 7th Avenue, 32d to 33d Streets	
Single room with bath	$4.50 to $8.50
Double room, double bed	7.00 to 10.50
Double room, twin beds	8.00 to 14.00
Hotel McAlpin, Broadway and 34th Street	
Single room and bath	4.00 to 7.00
Double room, double bed	6.50 to 10.00
Double room, twin beds	7.50 to 11.00
Suites	13.00 to 16.00
Hotel Governor Clinton, 7th Avenue at 31st Street	
Single room with bath	4.00 to 6.00
Double room, double bed	6.50 to 8.00
Double room, twin beds	8.00 to 9.50
Hotel New Yorker, 34th Street at 8th Avenue	
Single room, tub and shower	4.50 to 8.00
Double room, double bed	7.00 to 12.50
Double room, twin beds	8.00 to 12.50
Hotel Martinique, Broadway and 32d Street	
Single room with bath	4.00 to 5.50
Double room with bath	6.00 to 8.00
Double room, twin beds	6.50 to 8.00

REGISTRATION FEES

Members and nonmembers should register in advance by filling in the advance registration card included with the mailed announcement. As instituted last year, a registration fee of $3 will be required for members and $5 for nonmembers. These fees have made the meetings self-supporting and have been largely responsible for postponing the need for raising the annual dues of the Institute.

MEETING COMMITTEES

The following members comprise the Winter General Meeting Committee for 1950:

A. E. Knowlton, *Chairman;* G. J. Lowell, *Vice-Chairman;* J. J. Anderson, Jr., *Secretary;* W. J. Barrett, *Budget Co-ordination;* D. T. Braymer, *Registration;* J. L. Callahan, *Vice-President, District 3;* A. J. Cooper, *Smoker;* E. F. Farish, *Dinner-Dance;* R. W. Gillette, *Inspection Trips;* C. T. Hatcher, *Reception;* N. S. Hibshman, *Awards;* R. T. Oldfield, *Hotel Accommodations;* Mrs. D. A. Quarles, *Ladies Entertainment;* T. J. Talley, III, *Theater, Radio;* D. W. Taylor, *General Session;* A. R. Thompson, *Press Relations;* C. H. Willis, *Technical Program.*

The Ladies Entertainment Committee for the Winter General Meeting consists of the following:

Mrs. D. A. Quarles, *Chairman;* Mrs. G. T. Minasian, *Vice-Chairman;* Mrs. E. S. Banghart; Mrs. W. J. Barrett; Mrs. F. S. Black; Mrs. R. F. Brower; Mrs. O. E. Buckley; Mrs. J. L. Callahan; Mrs. A. J. Cooper; Mrs. A. F. Dixon; Mrs. R. W. Gillette; Mrs. C. T. Hatcher; Mrs. N. S. Hibshman; Mrs. R. K. Honaman; Mrs. A. E. Knowlton; Mrs. G. J. Lowell; Mrs. R. F. Miller; Mrs. R. T. Oldfield; Mrs. T. J. Talley, III; Mrs. D. W. Taylor; Mrs. C. H. Willis.

Second Conference Held on Subject of Instrumentation in Nucleonics and Medicine

More than 760 persons attended the highly successful Joint AIEE/Institute of Radio Engineers Conference on Electronic Instrumentation in Nucleonics and Medicine which was held at the Hotel Commodore in New York, N. Y., October 31, November 1-2, 1949. This was the second such joint technical meeting, the last one being held in the Engineering Societies Building, November 29–December 1, 1948.

The first day of the 3-day gathering was devoted to the nonnucleonic phases of electronics in medicine. Presided over by J. G. Reid, Jr., of the National Bureau of Standards, Washington, D. C., the two sessions of the first day covered such topics as low-frequency spectrography, electrocardiography, electrical methods of blood-pressure recording, and amplifiers and cathode-ray oscillographs for biological applications.

The second-day sessions, dealing with nucleonics in medicine, was presided over by Dr. G. W. Dunlap, General Electric Company, Schenectady, N. Y. Among the subjects covered were medical application of ionization radiation, dosage measurements, and various types of recorders and counters used in medical radiation work.

A round-table discussion on "Evaluation

Left, Dr. Harner Selvidge of the Bendix Aviation Corporation who presided on Wednesday at the Conference on Electronic Instrumentation in Nucleonics and Medicine. Right, Lewis L. Strauss of the Atomic Energy Commission who delivered an address at the Tuesday evening session of Radiation Hazards" was held during the evening of the second day. A 4-man panel consisting of A. L. Baker of Kellex Corporation, Dr. Ralph E. Lapp, formerly of the office of Naval Research, Admiral W. S. Parsons of the National Military Establishment, and Dr. Shields Warren, Director of the Atomic Energy Commission's Division of Biology and Medicine, participated in the discussion with Professor J. R. Dunning of Columbia University acting as moderator. Lewis L. Strauss, member of the Atomic Energy Commission, addressed the gathering following the round-table discussion.

The last day's sessions, presided over by Dr. Harner Selvidge, Bendix Aviation Corporation, Detroit, Mich., were concerned with nucleonic developments in industry and government. Various aspects of scintillation counters, solids for radiation detection, electric counting systems, improvements needed in nuclear instruments, and criteria in selecting radio-isotopes for industrial use were among the subjects discussed.

An interesting and very popular feature of the conference was an exhibit of commercially available nucleonic equipments. The largest of its kind to date, the exhibit featured the latest nucleonic instrumentation for the laboratory, field, and industry.

The great interest in the previous similar conference held and the demand for all the information disseminated in some permanent form prompted the committee to plan publication of the proceedings of the present conference. Accordingly, the full text of the papers with pertinent discussion presented is to be published in pamphlet form and copies will be made available sometime early this spring as soon as the papers and discussions can be collected, reviewed, and processed. Advance orders together with remittance ($3.50) for this publication should be sent to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Brief digests of most of the papers presented appear in this issue (*pp 68–71*); and a detailed program of the conference appeared in a previous issue (*EE, Oct '49, p 895*).

The hard work of several committees of both AIEE and IRE were responsible for the success of the conference. The sponsoring committees included:

For AIEE: Committee on Nucleonics, Committee on Electronics, Committee on Instruments and Measurements, Joint Subcommittee on Nucleonic Instrumentation, Joint Subcommittee on Electronic Aids to Medicine

For IRE: Professional Group on Nuclear Science, Nuclear Studies Committee

Personnel of the conference committees (which include members of both AIEE and IRE) were

Planning Committee: Dr. H. Selvidge (Chairman), R. L. Butenhoff, Dr. W. A. Geohegan, Dr. G. W. Dunlap

Papers Procurement and Program Committee: Dr. W. A. Geohegan (Chairman), Dr. G. Failla, Dr. G. W. Dunlap, R. L. Butenhoff, D. W. Atchley, Jr., E. E. Minett

Publicity: J. Luntz, Chairman

Publications: R. S. Gardner (Chairman), E. E. Grazda

Arrangements: R. D. Chipp, Chairman

Treasurer: Dr. Ward Davidson

Exhibitors Committee: D. W. Atchley, Jr., G. Leeds, L. W. Cronkhite, E. E. Minett, D. Collins

Exhibits: W. C. Copp (Manager), J. R. Marcett, Merton Young, Dayton Jones, Herbert White

Registration: R. D. Chipp (Chairman), Lillian Petranek, Ellen Leadbetter, Jean Jansson, Rosalie De Fabrizio, Florence Diciedue, Violet Ramsdale, Joan Tomkinson, Helen Yanciunas

The 4-man panel of scientific experts participating in the round-table discussion on "Evaluation of Radiation Hazards," held during the recent Joint AIEE-IRE Conference on Electronic Instrumentation in Nucleonics and Medicine, included (seated, left to right): Dr. Shields Warren, Director of the Atomic Energy Commission's Division of Biology and Medicine; Dr. Ralph E. Lapp, prominent author and formerly of the Office of Naval Research; Admiral W. S. Parsons of the National Military Establishment; and A. L. Baker, Vice-President, Kellex Corporation. Standing is Professor J. R. Dunning of Columbia University who acted as moderator

AIEE Board of Directors Meets During Fall Meeting in Cincinnati

A regular meeting of the AIEE Board of Directors was held in Cincinnati, Ohio, October 20, 1949, in connection with the Fall General Meeting, October 17–21.

Minutes of the Board of Directors meeting held in New York, N. Y., August 5, 1949, were approved.

Vice-Presidents DuVall, Hopkins, Seegar, Seeley, and Veinott reported briefly on cases in which they represented, or will represent, the Institute at various types of functions.

Recommendations on membership applications, adopted by the Board of Examiners at its meeting on September 15, 1949, were reported and approved.

The following actions of the Executive Committee as of September 22, 1949, recommended by the Board of Examiners, were reported and confirmed: 16 applicants transferred to the grade of Fellow; 44 applicants transferred and 30 elected to the grade of Member; 178 applicants elected to the grade of Associate; 167 Student members enrolled.

The following actions were taken upon recommendation of the Board of Examiners: 16 applicants were transferred to the grade of Fellow, and 64 were transferred to the grade of Member; 102 applicants were elected to the grade of Associate; 444 Student members were enrolled.

Disbursements for the past three months were reported by Chairman Yerkes of the Finance Committee, as follows, and were approved by the Board of Directors: August, $54,150.31; September, $47,813.71; October, $80,586.70.

Chairman Yerkes submitted a proposed budget prepared by the Finance Committee for the appropriation year beginning October 1, 1949, which, with some revisions, was adopted by the Board of Directors, with total estimated expenses amounting to $864,116.00.

The budget provided for an increase in the rate of travel allowances for Branch prize winners to District prize paper competitions from 7 cents per mile one way to 11 cents per mile one way, and for five District Student prize winners to the Summer General Meeting from 9 cents to 11 cents per mile one way, thus establishing a uniform basis of 11 cents per mile one way for all travel allowances.

Upon recommendation of the Committee on Planning and Co-ordination, the Board of Directors voted that the 1951 Winter General Meeting, in New York, be held January 22–26, instead of the following week previously authorized, the change being required because of a hotel conflict.

Amendments to the Institute bylaws were adopted, upon recommendation of the Committee on Constitution and Bylaws, as follows:

Section 6. The first sentence amended to read: "The names of applicants for admission to the Institute as Members or Fellows shall be posted....."

A third paragraph added, as follows: "The names of applicants for admission to the Institute as Associates after being recommended by the Board of Examiners shall be submitted to the Board of Directors and final action thereon shall not be taken until one month after receipt of such recommendation."

Section 7. Amended by addition of the following after the words "shall be posted in *Electrical Engineering..*" "with the request that any member objecting to the

1950 Summer and Pacific General Meeting

1950 LOS ANGELES 1950

N. B. Hinson, National Director, with M. V. Eardley, Vice-Chairman, Fred Garrison, Chairman, and E. L. Bettannier, Secretary, all of the General Committee, making plans for the 1950 AIEE Summer and Pacific General Meeting. Sponsored by the AIEE Los Angeles Section, the meeting will be held June 12–16 at the Huntington Hotel in Pasadena, Calif.

> transfer of any of the applicants shall make written communication to the Secretary, who shall refer such communication to the Board of Examiners for consideration....."

At its meeting on June 23, the Board of Directors referred to the Committee on Planning and Co-ordination a recommendation of the Sections Committee that a suitable certificate and a specially modified AIEE emblem be provided for past Section chairmen. Upon recommendation of the Committee on Planning and Co-ordination, the Board voted to disapprove this recommendation, on account of the difficulty and confusion likely to arise from extending such recognition to other voluntary workers.

The following members of the Board of Directors were selected to serve on the AIEE Nominating Committee: A. H. Frampton, M. D. Hooven, F. O. McMillan, Elgin B. Robertson, and E. W. Seeger. A. C. Montieth and C. G. Veinott were designated alternates.

President Fairman was authorized to appoint a successor to F. M. Farmer as one of the Institute's two representatives on the Engineering Societies Monographs Committee, Mr. Farmer having declined reappointment for the present year.

Professor F. O. McMillan, Chairman of the Committee on Student Branches, reported on the Inter-Society Conference on Engineering Student Branches, September 12, which he attended as AIEE representative, and asked for instructions. The Board directed that copies of President Fairman's address on October 18, at the general session of the Fall General Meeting, on the subject of "Professional Unity at the Grass Roots," be distributed to the representatives in the Inter-Society Committee, with the statement that the Board of Directors is definitely in favor of joint Branches.

Upon request of the Engineers' Council for Professional Development, approval was given for the appointment of Doctors F. E. Terman and H. H. Skilling to the Region VI Committee of the ECPD Committee on Engineering Schools.

Secretary Henline presented the principal conclusions reached at the Conference of Representatives of Engineering Societies of Western Europe and the United States held in London, England, September 19–23, 1949.

Authorization was given for the organization of a Student Branch at Howard University, Washington, D. C.

Other matters were discussed, reference to which may be found in future issues.

There were present the following:

President—J. F. Fairman, New York, N. Y.

Past Presidents—B. D. Hull, Dallas, Tex.; Everett S. Lee, Schenectady, N. Y.

Vice-Presidents—J. L. Callahan, New York, N. Y.; W. C. DuVall, Boulder, Colo.; A. H. Frampton, St. Catharines, Ontario, Canada; Ralph A. Hopkins, Los Angeles, Calif.; G. N. Pingree, Dallas, Tex.; E. W. Seeger, Milwaukee, Wis.; W. J. Seeley, Durham, N. C.; Victor Siegfried, Worcester, Mass., C. G. Veinott, Lima, Ohio

Directors—W. J. Barrett, Newark, N. J.; E. W. Davis, Cambridge, Mass.; W. L. Everitt, Urbana, Ill.; C. W. Fick, Cleveland, Ohio; R. T. Henry, Buffalo, N. Y.; M. D. Hooven, Newark, N. J.; F. O. McMillan, Corvallis, Oreg.; A. C. Monteith, Pittsburgh, Pa.; Elgin B. Robertson, Dallas, Tex.; E. P. Yerkes, Philadelphia, Pa.

Secretary—H. H. Henline, New York, N. Y.

Edison Medal Awarded to Dr. K. B. McEachron

The 1949 Edison Medal of the AIEE has been awarded by the Edison Medal Committee to Dr. Karl B. McEachron "For his contributions to the advancement of electrical science in the field of lightning and other high-voltage phenomena and for the application of this knowledge to the design and protection of electric apparatus and systems."

Dr. McEachron is so well known in the field of lightning research and high-voltage investigation that little needs to be said about his career. He was formerly in charge of the High-Voltage Engineering Laboratory of the General Electric Company at Pittsfield, and for the development of Thyrite, a material used for lightning arresters, he received the Charles A. Coffin Award and the Longstreth Medal of the Franklin Institute. Under his direction, the 10,000,000-volt artificial lightning generator used at New York's World Fair was developed. He has served on many committees and was a Director of the Institute, 1935–40, and Vice-President of the North Eastern District, 1942–44. A brief biography of Dr. McEachron appears in this issue (*p 83*).

The medal will be presented during the Winter General Meeting, January 30–February 3, 1950.

Hoover Medal to Be Presented to Dr. Jewett Posthumously

The 1949 Hoover Medal was awarded to Dr. Frank B. Jewett prior to his death on November 18, 1949. The citation for the award is as follows:

• • •

FRANK B. JEWETT

Great pioneer of industrial research, leader in molding scientific and engineering work to the needs of humanity, distinguished organizer of scientific effort for the service of the nation in war and peace.

• • •

Dr. Jewett had a long illustrious career, having served as Vice-President-in-Charge of Development and Research at the American Telephone and Telegraph Company for nearly 20 years, 1925–44, and as President of the Bell Telephone Laboratories from 1925–40. He had received a number of honorary degrees and awards, including the Edison Medal (1928), the Faraday Medal (1935), the Washington Award (1938), and the Medal for Merit (1946). He was a Past-President of the AIEE and Member for Life, as well as a former President of the National Academy of Sciences. A brief biography of Dr. Jewett appears in this issue (*p 86*).

The Hoover Medal is awarded by the American Society of Civil Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the AIEE. The medal will be presented posthumously during the Winter General Meeting of the Institute, January 30–February 3, 1950.

District 2 Executive Committee Holds Meeting in Cincinnati

A meeting of the AIEE District 2 (Middle Eastern) Executive Committee was held in the Netherland Plaza Hotel, Cincinnati, Ohio, on October 17, 1949, during the AIEE Fall General Meeting in that city. The morning session included reports on recent Institute activities, the District Prize Paper competition, a discussion of plans for future

AIEE meetings in District 2, a conference on membership activities led by M. L. Lehman, District 2 Vice-Chairman of the Membership Committee, and an address, "To Be or Not to Be," by AIEE President Fairman. The afternoon session continued with a conference on Section–Branch co-operation and student activities under the chairmanship of K. F. Sibila; a conference on Section operation and management with H. H. Wagner, representative of the Sections Committee, presiding; various items of District business; and a discussion of the establishment of a Section Growth Award.

Among other actions, the District Executive Committee nominated I. Melville Stein of the Philadelphia Section for the office of President of the Institute for the term beginning in August 1950. Mr. Stein is Vice-President and Director of Research for the Leeds and Northrup Company. H. A. Dambly of the Philadelphia Section was named as the District 2 member of the Institute Nominating Committee, and a new District Co-ordinating Committee was named with the following to serve for the coming year: N. J. Green, Chairman of the Columbus Section; W. F. Henn, Chairman of the Philadelphia Section; Dixon Lewis, Chairman of the Washington Section; and R. L. Oetting, Chairman of the Cleveland Section. Exofficio members are C. G. Veinott, Vice-President; K. F. Sibila, Chairman of the District Committee on Student Activities; and W. A. Dynes who is the District 2 Secretary.

Of particular interest was the consideration of a "Growth Award" aimed at setting up a simple yardstick for determining how good a job the Section is doing, and the Co-ordinating Committee was instructed to work out details incidental to the establishment of such an award. The case for a Growth Award was stated as presented in the following paragraphs:

"*Recognition of Section Growth.* Sections, like any other body, must grow or die. When a Section ceases to grow, it will probably start to decay, even though the decaying process may be long or short. In order to encourage growth, a plan is proposed for recognizing growth of individual Sections. Two over-all useful yardsticks which tell how well a Section is serving the interests of its members and prospective members are: increase in number of members; and increase in over-all attendance at meetings. The increase in attendance may be the result of more members, better programs, or more activities, such as discussion groups.

"In order to put large and small Sections on an equal basis, the growth obviously should be measured in per cent. Assuming both factors to be equally important, the measure of growth is given by:

Growth = per cent net change in membership + per cent change in over-all attendance

"These changes are to be added algebraically. For purposes of figuring growth, when territory and members are transferred from one Section to another, the number of members involved in the transfer will not be included in the total membership of either Section.

"The foregoing formula provides a simple method for rating Sections as to their growth without being subject to human errors or prejudice."

District 2 Student Committee Meets at University of Akron

With the University of Akron as host, the District 2 (Middle Eastern) Student Activities Committee held its 1949 meeting on November 4 and 5. Nineteen of the 24 Branches were represented and a number of students in addition to the official delegates came to get first-hand information on Branch operation. In addition, C. G. Veinott, Vice-President from District 2, and W. A. Dynes, District Secretary, also attended. The first-day program, arranged by K. F. Sibila, Chairman of the District Committee on Student Activities, included separate conferences for Student Counselors and Student Branch Chairmen, an inspection trip to the Goodyear Tire and Rubber Company, inspection of the engineering laboratories of the University of Akron, a banquet in the Student Building, and a discussion of the "River Lake Conveyor Belt." The second day brought the meeting to a close with joint Counselor-Student Chairman conferences.

The discussion of Section-Branch co-operation brought out that Section Chairmen can encourage student participation by writing and inviting them to attend the meetings even though they cannot attend the dinner. Sections also can have the Student Chairman or some of the officers sit in on the Board meetings. Symposiums have been held by some Sections and the students prefer men from the various industries who can tell them about job opportunities, what salaries they may expect, and what will be demanded of them in industry. It was noted that the prime objective of this co-operation is to let the students see how the Institute fits into their professional life.

The interchange of ideas on Branch activities was quite active. Some Branches intend to charter busses and visit various types of industries. Others are planning to attend the Winter General Meeting where the inspection trips appeal particularly. The use of panel discussions and active question periods after speakers have presented talks on the students' level have encouraged participation.

Inasmuch as the District 2 Student Branch *News Letter* is edited by a different Branch each year, Villanova College will take over the task from Ohio State University for 1950. This news letter tells of the happenings throughout the District and is intended as a source of novel ideas for the Branches.

In closing, the 1950 meeting of the committee was scheduled for George Washington University in Washington, D. C., during that city's sesquicentennial celebration. J. S. Antel of George Washington University was selected as next Chairman of the District Committee on Student Activities. The prize paper competition was scheduled for Lafayette College at the end of April and J. G. Reifsnyder, Layfayette Counselor, will arrange for this function.

Fellowship Applicants Must File by February 15

Candidates for the Charles LeGeyt Fortescue Fellowships should file applications on the form provided by AIEE so that they reach the Secretary of the Fellowship Committee by February 15, 1950. Awards will be made not later than April 1. Copies of the application forms are available at accredited colleges or at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end the Westinghouse Electric Corporation, with which Doctor Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates, selected by the AIEE committee which administers the fund, receive a minimum allowance of $500, and additional allowance may be granted at the discretion of the committee.

It is intended that candidates shall pursue their studies at accredited engineering schools and engage in research problems meeting the approval of the Fellowship Committee. To be eligible, the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution at which the graduate work is to be undertaken.

South Carolina Section Awarded District 4 Membership Plaque

According to a recent announcement, the AIEE South Carolina Section has won the Membership Plaque awarded annually in District 4 (Southern) to the Section showing the greatest percentage gain in membership in the preceding year. This is the third time the award has been made. The previous winners were the Alabama Section for 1946–47 and the Louisville Section for 1947–48.

The plaque will be formally presented to South Carolina at a meeting in the near future.

Detroit to Be Site of Welding Conference

A Special Technical Conference, which is being sponsored by the AIEE Committee on Electric Welding, will be held in the Rackham Memorial Building, Detroit, Mich., April 5–7, 1950. Arrangements have been made for persons attending the conference to make reservations at the Detroit-Leland Hotel.

The conference will be comprised of six sessions to be held two each day, morning and afternoon, for three days. The sessions will be devoted to the following subjects: arc research, arc machines, instrumentation, power supply, resistance machines, and special processes. Each session will consist of three or four papers and many of these will be accompanied by demonstrations, which should ensure a conference as interesting and valuable as any which has been held during the past few years.

The complete program of the conference will be published in a subsequent issue of *Electrical Engineering.*

G. C. B. Rowe Appointed Associate Editor for AIEE

George C. Baxter Rowe, formerly technical editor of the Derring Milliken Research Trust, Greenwich, Conn., has joined the AIEE publications staff as associate editor to succeed Edward E. Grazda (*see p 84*).

Mr. Rowe was born February 2, 1897, in Philadelphia, Pa., and was graduated from Union College, Schenectady, N. Y., with the degree of bachelor of science in electrical engineering in 1920 after serving in the Officers Material School, United States Naval Reserve. After four years in the test departments of the General Electric Company, Schenectady, N. Y., and the Atlantic Refining Company in Philadelphia, he joined the staff of *Radio News* and later became managing editor of *Radio Engineering* and *Aviation Engineering*. In 1933 he became associated with John F. Rider Publisher, Inc., where he remained until 1948 as managing editor with the exception of a 2-year leave of absence during which he was Senior Editor, Signal Service at Large, stationed at the Training Literature Division of the Southern Signal Corps School, Camp Murphy, Fla., where he edited training manuals on radar equipment.

In September 1943, Mr. Rowe enlisted in the United States Coast Guard Temporary Reserve in which he served in Florida until May 1944, and then as Public Relations Officer in Flotilla 1002, Brooklyn, N. Y., until the end of the war. He has written magazine articles on various phases of radio and has collaborated on texts pertaining to the electronics field.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Communication Group

Committee on Telegraph Systems. (*I. S. Coggeshall, Chairman; J. A. Duncan, Jr., Vice-Chairman; E. C. Chamberlain, Secretary.*) This committee has completed its plans for offering three papers and holding a conference on facsimile at the 1950 Winter General Meeting (*see p 72*).

Committee on Radio Communications Systems. (*G. T. Royden, Chairman; E. D. Becken, Vice-Chairman; A. C. Dickieson, Secretary.*) This committee has arranged for the presentation of papers at sessions on mobile radio systems and microwave communication at the 1950 Winter General Meeting. The committee formerly operated as a subcommittee under the Communication Committee and only recently became a full committee. Its chairman has been with various units of the International Telephone and Telegraph system for more than 25 years, its vice-chairman has been with the Radio Corporation of America for over 15 years, while Secretary Dickieson has been a member of the technical staff of Bell Telephone Laboratories for 25 years. The committee plans to meet during the Winter General Meeting to arrange papers for the Summer and Pacific General Meeting at Pasadena, Calif. As many devices developed for use with carrier current on power lines may be readily adapted to use microwave links, arrangements have been made for S. C. Leyland, a member of the Carrier Current Committee, to co-operate with D. D. Grieg of the Committee on Radio Communications Systems for the purpose of selecting papers on that subject for presentation at AIEE meetings.

Courtesy of *Coal Age*

At the meeting of the Committee on Mining and Metal Industry, left to right seated: E. G. Schlup, D. E. Renshaw, T. B. Montgomery, A. C. Muir, J. J. Fitzgibbon. Standing: H. P. Musser, L. H. Harrison, J. M. Downie, A. B. Chafetz, L. W. Scott, C. O. Wood

Industry Group

Committee on Mining and Metal Industry. (*T. B. Montgomery, Chairman; A. C. Muir, Vice-Chairman.*) This committee held a meeting on October 19, 1949, during the Fall General Meeting in Cincinnati, at which time D. E. Renshaw was appointed Liaison Representative between the American Mining Congress and the committee, and F. W. Cramer, Liaison Representative between the Association of Iron and Steel Engineers and the committee. J. J. Fitzgibbon was appointed Chairman of the Subcommittee on Mining. Committees were selected to study and recommend themes, subjects, and authors for the mining and metal sessions at the Summer and Pacific General Meeting next June.

J. J. Orr, Chairman of the Industry Co-ordinating Committee, was present at this meeting and set forth to the committee a 5-point program of functional objectives as follows:

(*a*). Dissemination of practical knowledge and experience to the membership.

(*b*). Promote and organize discussion meetings or conferences.

(*c*). Promotion and organization of special technical conferences.

(*d*). Sponsorship of work leading to Standards.

(*e*). Preparation of special publications.

For each of the subcommittees and the committee as a whole, a program of activity was set forth as follows:

(*a*). Express to AIEE members in the industries served by this committee the broad objectives of the Industry section of the Institute in detail.

(*b*). Obtain a short writeup of each committee member to be tabulated in a directory, in order to promote better acquaintanceship within the committee.

(*c*). Record papers given in the meetings as sponsored by the committee since its origin in 1947.

(*d*). Tabulate AIEE Standards which already exist and apply to this committee.

(*e*). Prepare a manual for guidance in committee work.

(*f*). Establish themes for meetings sponsored by the committee.

(*g*). Co-ordinate the activity with other organizations within the industries which are doing work allied with the committee's activities.

Power Group

D-C Machinery Subcommittee of the Committee on Rotating Machinery. (*B. H. Caldwell, Chairman.*) The first meeting of the 1949–50 members of the D-C Machinery Subcommittee was held as a luncheon meeting immediately following the October 17 morning session at the Fall General Meeting in Cincinnati.

Of primary interest was the paper, "Temperature Rise Values for D-C Machines—Part II," which was prepared by the 1948–49 committee and presented at the morning session. Much interesting discussion developed and agreement was reached for the basis of the written closure to be published with the paper. Definite recommendations will now be forwarded to the Rotating Machinery Committee for consideration.

A very satisfactory progress report was given on "Procedure for Calculating Short-Circuit Currents in D-C Machines." This project was materially advanced last year, and the material was considered to be in satisfactory shape for publication. It was recommended that A. G. Darling prepare a paper on the subject, and submit it for presentation at the Winter General Meeting.

Collection and correlation of information relating to "Armature Circuit Inductance of D-C Machines" was accepted as a project for the subcommittee. The need for technical papers covering practical methods for measuring armature circuit inductance and for methods of computing this inductance from machine dimensions and winding data was stressed.

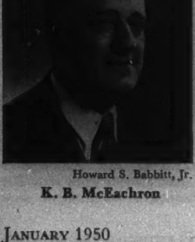
Science and Electronics Group

Subcommittee on Electron Tubes of Committee on Electronics. (*H. C. Steiner, Chairman; D. E. Marshall, Secretary.*) Two technical sessions have been arranged by the Electron Tube Subcommittee of the Electronics Committee for presentation at the Winter General Meeting (*see page 72*).

AIEE PERSONALITIES .....

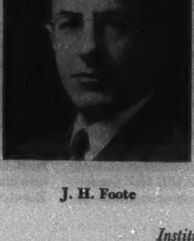
K. B. McEachron (A '14, F '37) has been awarded the 1949 Edison Medal "for his contributions to the advancement of electrical science in the field of lightning and other high-voltage phenomena and for the application of this knowledge to the design and protection of electric apparatus and systems." Dr. McEachron, who is Manager of Engineering, Transformer and Allied Products Division, General Electric Company, Pittsfield, Mass., will receive the medal at the Winter General Meeting. (See page 80 of this issue). He was born in Hoosick Falls, N. Y., in November 1889. He was graduated from Ohio Northern University in 1913 with degrees in both electrical and mechanical engineering. After a year with the General Electric Company devoted mainly to high-voltage investigations, he returned to Ohio Northern to become an instructor in electrical engineering from 1914 to 1918. For the next four years he was an instructor and also research associate at Purdue, where he continued his investigations of high-voltage phenomena. In 1920 he received a master of science degree in electrical engineering from Purdue. Later, both universities granted him honorary doctorate degrees—Ohio Northern in 1938, Purdue in 1941. In 1922 Dr. McEachron joined the General Electric Company at Pittsfield, Mass., as head of the Lightning Arrester Development and Research Section. Sensing a need for improved equipment to measure impulse voltages, he and his associates obtained and further developed the cathode-ray oscillograph. In 1924 they succeeded in recording the first oscillogram of single transient voltages of only a few microseconds duration. His first important invention was a nonlinear resistance material called Thyrite. It was first applied in station-type lightning arresters and later in a wide variety of applications. For the development of Thyrite Dr. McEachron received in 1931 the General Electric Coffin Award, and in 1935 the Franklin Institute awarded him the Edward Longstreth Medal. In addition to his work with artificial lightning in the laboratory, he initiated field studies in which behavior of artificial lightning on actual transmission and distribution circuits was observed with the cathode-ray oscillograph. In 1933, Dr. McEachron was appointed Engineer in charge of the High Voltage Engineering Laboratory. Under his direction was developed much of the modern technique of measurement of artificial and natural lightning, and the behavior of component insulations and complete transformers, when subjected to various types of impulse voltage, was investigated. The activities of the Laboratory were broadened to include more field investigations. Perhaps the most widely known, because of its popular interest and contribution to basic knowledge, was the study of lightning strokes to the tower of the Empire State Building. By means of cathode-ray oscillographs, magnetic oscillographs, and special cameras, lightning phenomena were recorded over a range of time from microseconds to seconds. From 1940 until appointment as Assistant Works Engineer in 1945, Dr. McEachron was Designing Engineer of Power Transformers. On September 1, 1949, he was appointed Manager of Engineering, Transformer and Allied Product Divisions. Dr. McEachron has been continuously active in Institute affairs. He became Chairman of the local Section in 1936, was elected Vice-President of District 1 in 1942, and also, he served as a member of the national Board of Directors from 1936 to 1940. Among other AIEE activities, he has been a member of eight general committees, two technical committees, and three special committees, serving on most of them for several terms. While at Purdue in 1920, Dr. McEachron published the first of his many engineering papers. Alone or in collaboration with fellow engineers, he has presented or published over 60 technical papers. From 1937 to 1945 he was a member of the National Advisory Committee on Aeronautics, Subcommittee on Lightning Hazards to Aircraft. During World War II he served the United States Government as Chairman of the Advisory Committee on Lightning Protection, Safety and Security Division. He has been a member of a panel of the United States Research and Development Board.

J. H. Foote (A '18, F '32), formerly Supervising Engineer of Commonwealth and Southern Corporation, has been elected a Vice-President of its successor, Commonwealth Services, Inc., New York, N. Y., and President of the engineering subsidiary in Jackson, Mich., Commonwealth Associates, Inc. He has been with the Commonwealth and Southern and associated organizations since 1915 and in his new position will guide engineering policies in the change from a service company to an independent consulting company. Mr. Foote is Chairman of the Michigan State Board for Registration of Professional Engineers, and is a member of the AIEE committee on this subject, as well as numerous other committees of AIEE. At the same time, seven other new officers in Jackson, Mich., were appointed. **J. R. North** (A '21, F '41), who was Chief Electrical Engineer of Commonwealth and Southern Corporation, has been elected a Vice-President of Commonwealth Associates, Inc. He has been with the company and its predecessor firm for 25 years. Mr. North has been a Director of AIEE and has served as Chairman of the Planning and Coordination Committee, the Protective Devices Committee, and the Standards Committee. He has served in all of the offices of the Michigan Section, including Chairman in 1934–35. **E. F. Dissmeyer** (M '36, F '47) has been appointed General Staff Engineer of Commonwealth Services. He has been with the organization over 23 years and was most recently responsible for system planning and special engineering studies. In his new position he will assist in the general coordination of planning and general engineering. Mr. Dissmeyer is Chairman of the Michigan Section and a member of the Rotating Machinery and Power Generation Committees. **R. J. Wensley** (A '28, M '35) has been appointed Supervisor of Operations. He will be responsible for operational and personnel activities, job progress, and procedures. Mr. Wensley was General Manager of Wilcox Gay Corporation prior to joining the Commonwealth organization about one year ago. **F. E. Sanford** (A '28, F '46) has been appointed Assistant Chief Electrical Engineer of Commonwealth Services. Formerly, he directed several research projects for Copper Wire Engineering Association and was a consultant for Line Material Company, Milwaukee, Wis. Mr. Sanford was a member of the AIEE Special Subcommittee on Professional Activities (1945–47). **W. R. Brownlee** (A '35, M '38) has been appointed Supervisor of Power Systems Engineering. He has been with the organization and an affiliated company over 20 years, his responsibilities having included load division and stability analyses, protective relaying applications, operating engineering, and interconnection studies. In his new position he will direct engineering studies of power systems. Mr. Brownlee

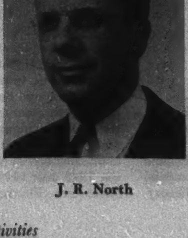


Howard S. Babbitt, Jr.

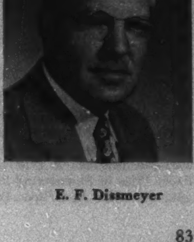
K. B. McEachron



J. H. Foote



J. R. North



E. F. Dissmeyer

C. F. Wagner

E. E. Grazda

served as Chairman of the Relay Committee during its first two years of operation and is now a member of the System Engineering Committee and Vice-Chairman of the Power Co-ordinating Committee. **H. R. Wall** (A '39, M '45) has been appointed Supervisor of Distribution Systems Engineering. He has been associated with this organization and with associated companies for 13 years, and previously with The Cleveland Electric Illuminating Company. With his present organization, he has been engaged successively in station design, technical applications and investigations, system protection, system operating problems, and system planning. **J. N. Gosinski** (A '31), who has been appointed Staff Engineer, has been with the organization since 1923 and most recently has been responsible for engineering studies relating to distribution system planning and operation. In his new position, he will conduct load and utilization studies and economic analyses.

C. F. Wagner (A '20, F '40) has been appointed Consulting Engineer in the central station and power fields for the Westinghouse Electric Corporation, East Pittsburgh, Pa. He has been Manager of the Central Station Section of the Westinghouse Industry Engineering Department for the last eight years. Mr. Wagner received his bachelor's degree in electrical engineering from the Carnegie Institute of Technology in 1917. Then, he did a year's graduate work at the University of Chicago. He holds an honorary degree of doctor of engineering from the Illinois Institute of Technology and is a member of the fraternities, Tau Beta Pi, and Sigma Xi. Upon joining the Westinghouse Company in 1918, he was sent to the Research Engineering Department. In 1923, he was transferred to the consulting staff of Dr. C. L. Fortescue. For a short period he returned to the Research Laboratories, and in 1934 was transferred to the Central Station Section. In 1938, he became Consulting Transmission Engineer and in 1941 Manager of the Central Station Section. Mr. Wagner has contributed more than 60 papers and articles to technical literature, over 20 of which were presented before the AIEE. He won with R. D. Evans the Belgian George Montefiore Prize for the "best original work contributing to the scientific advancement in the technical application of electricity." He was also awarded in 1938 the AIEE Best Paper Prize in Engineering Practice, and in 1942 the AIEE Best Paper Prize in Theory and Research. Mr. Wagner has been Chairman of the Transmission and Distribution Committee and the Publication Committee. Among other committees on which he has been active are the Transformer Subcommittee, the Planning and Co-ordination Committee, the Technical Program Committee, the Power Co-ordinating Committee, and the Standards Committee. He has about 30 patents to his credit. In 1945 he was sent by the United States Government as a member of a committee to investigate electrical technological developments in the central station field that might have taken place in Germany during the war. Also in 1949 he represented the United States at the conference of the International Electrotechnical Commission at Stresa, Italy on insulation co-ordination.

E. E. Grazda (A '42), formerly Associate Editor of *Electrical Engineering*, has joined the staff of *Electrical Equipment*, Sutton Publishing Company, New York, N. Y. Mr. Grazda came to the AIEE publications department in the spring of 1947 from the Minneapolis-Honeywell Regulator Company in Milwaukee, Wis. Born in New York, N. Y., September 15, 1915, he was graduated from New York University in 1942 with a bachelor of science degree in electrical engineering. He was Assistant Editor of *Electronics*, New York, in 1941 and 1942 and was also Junior Engineer with Lincoln Walsh, Consulting Engineer in 1942. He joined Minneapolis-Honeywell in 1943 as Domestic Field Engineer and one year later was named Senior Field Engineer. As such, he was Senior Technical Representative on the 20th Bomber Command's B-29 project in China and India. He instructed army personnel in the theory, operation, and maintenance of electronic flight and turbosupercharger controls; supervised the design and construction of test equipment and depot repair facilities; and acted as Consultant to the Army Air Forces. Also, he instructed maintenance personnel of the Central African Wing of the Air Transport Command and assisted in preparing a postwar training program while on Okinawa. Minneapolis-Honeywell designated him Design Test Engineer in 1945, from which post he came to AIEE. In addition to his editorial duties, Mr. Grazda worked with R. S. Gardner of the AIEE headquarters staff on publication matters related to special technical conferences and served on the committees of both the 1948 and 1949 joint AIEE-IRE Conferences on Electronic Instrumentation in Nucleonics and Medicine. He is a member of the Institute of Radio Engineers and Eta Kappa Nu.

M. B. Long (A '19) has been elected Treasurer of the Bell Telephone Laboratories, New York, N. Y. In addition, he has been appointed Assistant to the Executive Vice-President. A 1917 graduate of the University of Nebraska, he joined the Laboratories in 1919, after two years with the National Bureau of Standards. From 1925 to 1930, he was Educational Director. Then, as Assistant Director of Publication, he coordinated the Bell System exhibits at the Chicago and New York World's Fairs and the Expositions at Dallas and San Diego. He headed the Murray Hill Project Department (which was discontinued last summer after having served its purpose) since its inception in 1939.

C. L. Matthews (A '09, F '27, Member for Life), President and one of the founders of the W. N. Matthews Corporation, St. Louis, Mo., was awarded a Fifty Year Gold Certificate at the recent Atlantic City meeting of the National Electrical Manufacturers Association in recognition of his one-half century of continuous service to the electrical industry. Mr. Matthews' earliest business experience was in the electrical supply and telephonic fields. In 1899, he and his brother, W. N. Matthews, founded the organization which he now heads.

J. S. Cotton (M '45), Consulting Engineer of San Anselmo, Calif., has been engaged by the state of Israel to prepare a master plan and designs for irrigation and power development of Israel. This involves conducting the waters of the Jordan river from the northern boundary to the southern end of the country for irrigation, and conducting Mediterranean sea water to the Dead Sea, which is about 400 meters lower than the Mediterranean, for the generation of power. The sea water, after generating power, will be evaporated.

W. F. Hess (A '32, F '48) of the Rensselaer Polytechnic Institute, Troy, N. Y., along with two coauthors, has been awarded first prize for the best paper from a university source in the 1949 Resistance Welder Manufacturers Association Prize Contest. Title of the paper was "Optimum Flash Welding Conditions." Dr. Hess also helped to write the paper which won second prize in the competition for papers from a university source. It was titled, "Further Studies in Projection Welding."

H. S. Fitch (A '18, M '46) a Vice-President of the West Penn Power Company, Pittsburgh, Pa., has been elected President of the Pennsylvania Electric Association. At West Penn, Mr. Fitch has full responsibility for the management of the Power Department. He started with the organization 35 years ago as a System Operating Engineer, rose through the ranks, and became Vice-President early this year.

K. B. Crawford (M '43), Electrical Engineer specializing in management work with The Rural Electrification Administration since

1942, has been named head of REA's Power Management Section of the Power Division. Before his present appointment, Mr. Crawford was Equipment Specialist on the staff of the Chief of the Management Division.

R. H. Reynolds, Jr. (A '40) has been appointed District Sales Representative for the General Electric Company's Electronics Department, covering the New England, New York, and Atlantic Districts. Headquartered in New York, N. Y., he will sell marine electronic equipment. Formerly, Mr. Reynolds was in the company's Broadcast Sales Section.

C. E. Sisson (A '19, F '44) has been appointed Field Secretary of the Engineering Institute of Canada. His headquarters will be in Toronto, Ontario. Prior to joining the Institute, he was with the Canadian General Electric Company at Peterboro and Toronto, and for a number of years before retiring from the company, he held the post of Managing Engineer at the Davenport plant.

M. A. Edwards (M '40, F '47) and **J. J. Smith** (A '19, M '48) have been named associate engineers of the General Electric Company's General Engineering and Consulting Laboratory, at Schenectady, N. Y. Both have been serving as assistant engineers. Dr. Edwards will be in charge of the laboratory's nine technical divisions while Dr. Smith will supervise service group activities. With General Electric since 1929, Dr. Edwards has received the company's Coffin Award three times. Dr. Smith has served with the firm for 31 years.

F. W. Godsey, Jr., (A '30, F '45) has been designated Manager of the Westinghouse Electric Corporation's newly created Special Products Development Division at East Pittsburgh, Pa. Formerly, he managed the New Products Department, absorbed by the group which he now heads. Mr. Godsey joined Westinghouse in 1940 and was appointed Manager of the New Products Department in 1945.

G. L. MacLane, Jr., (A '40) has been named Manager of the Engineering Laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa., succeeding **T. L. Spooner** (A '12, F '29) who retired recently after 40 years of service with the company. Mr. MacLane joined Westinghouse in 1936 and was appointed Assistant Manager of the Laboratories at the beginning of this year. Mr. Spooner is a Member for Life.

J. P. Brown (A '46) is slated to work in the newly formed Missile Controls Design Group of Lear, Incorporated, at Los Angeles, Calif. He will help in the development of automatic controls systems to be applied to airframes being manufactured by west coast firms. Formerly, Mr. Brown was located at the company's Grand Rapids, Mich., branch.

C. E. Ide (A '16, M '38), former Executive Vice-President and General Manager of the Toledo (Ohio) Edison Company has been made President. He succeeds **C. L. Proctor** (A '08), who becomes Chairman of the Board. Associated with electrical utilities for 35 years, Mr. Ide joined Toledo Edison in 1945. Mr. Proctor, who had been named President in 1940, has been identified with the company since 1925. He is a Member for Life of the Institute.

J. E. McCormack (A '27, F '44), formerly Staff Engineer in the Electrical Engineering Department, Consolidated Edison Company of New York (N. Y.), Inc., has been designated Chief Distribution Engineer. He heads the company's newly organized Transmission and Distribution Bureau. Mr. McCormack began his career in the utility industry with the Queens Electric Light and Power Company, which firm is now a part of Consolidated.

E. W. Kenefake (A '43, M '48) has been appointed Section Engineer for Carrier-Current Equipment, General Electric Company, Schenectady, N. Y. Mr. Kenefake joined General Electric in 1936. Subsequently, he worked in the Vacuum Tube Division, and in 1938 was named Assistant Section Engineer in charge of the development and design of carrier-current equipment. He held that position until his present appointment.

J. D. Ryder (A '40, M '46), Professor of Electrical Engineering and Assistant Director of the Engineering Experiment Station, Iowa State College, Ames, has been named Professor and Head of the Department of Electrical Engineering, University of Illinois, Urbana. He succeeds **W. L. Everitt** (A '25, F '36), who has become Dean of the College of Engineering. Mr. Everitt is a Director of the AIEE.

R. S. Kersh (A '42, M '45) has become Manager of Central Station Sales, Westinghouse Electric Corporation, East Pittsburgh, Pa. A 20-year veteran of Westinghouse, Mr. Kersh had been appointed Manager of Industrial Sales in 1947.

G. R. Woodman (A '27), formerly Superintendent of Hydro Generation for the Southern California Edison Company, Los Angeles, has been appointed Superintendent of Generation. He joined the company in 1923 and became Hydro Superintendent in 1944. **A. C. Werden** (A '45), who has been Assistant Superintendent of Hydro Generation since 1945, succeeds to Mr. Woodman's former post. **T. C. Stavert** (A '48), formerly Hydro Superintendent in the company's southern division, fills Mr. Werden's previous position. In other company changes, **W. E. Montgomery** (A '35, M '43) was advanced from Assistant Operating to Operating Engineer, while **A. G. Denyer** (A '39) became Assistant Operating Engineer. He was formerly System Planning Engineer.

C. J. Breitwieser (A '33, M '44) has been awarded an honorary degree of doctor of science by his alma mater, the University of North Dakota. Dr. Breitwieser is chief of the Electronics and Engineering Laboratories for the San Diego, Calif., Division of Consolidated Vultee Aircraft Corporation. Citation for the degree pointed out his contributions in the fields of guided missiles, electrical systems for large aircraft, and radiotherapy. Dr. Breitwieser joined Consolidated Vultee in 1942 as a staff engineer in charge of radio and electrical engineering. He is a member of the Research and Development Board for the National Military Establishment. Currently serving on the Electronics Committee, he was a member of the Committee on Air Transportation, 1947–48.

E. M. Wood (A '09, F '43 Member for Life), formerly System Planning Engineer and Head of the System Planning Department, of the Hydro-Electric Power Commission of Ontario, Toronto, has been appointed consulting engineer on problems related to system planning and electrotechnical matters. **G. D. Floyd** (A '19, M '28) will fill Mr. Wood's former position. Previously, he had been Senior Planning Engineer.

J. C. Fink (A '46), formerly Manager of the Industry Engineering Department of the Westinghouse Electric Corporation, East Pittsburgh, Pa., has been named assistant to the Vice-President in Charge of Engineering. From 1928 to 1945 he was a member of the Marine and Aviation Section of the Industry Engineering Department with responsibility for the co-ordination and application of electric equipment for shipboard and wind tunnel use. In 1945, he became manager of the General Mill Section of that department, and three years later he was named manager of the entire Industry Engineering Department.

Samuel Horelick (A '17, F '48), for the last 20 years President of the Pennsylvania Transformer Company, Pittsburgh, has been elected to the firm's newly created position of Chairman of the Board. At the same time, **W. E. Kerr** (M '37, F '48) was named President. He had been Vice-President and Treasurer of the organization since 1929. **W. R. Swoish** (A '41) was elected Vice-President. He continues in his former post of Sales Manager.

T. D. Talmage (M '40), Communications Engineer for the Tennessee Valley Authority, Chattanooga, Tenn., has been elected to membership in the Chattanooga Engineers' Club. Mr. Talmage served on the Communication Committee, 1944–1946, as well as on the Joint Subcommittee on Power System Applications of Carrier Current. He is currently a member of the Carrier Current Committee and Chairman of the East Tennessee Section of the AIEE.

W. B. Thompson (A '42, M '47) has resigned from his position as Chief Electrical Engineer of the Firestone Tire and Rubber Company of Tennessee, Memphis, to open a consulting engineering office in the same city. He will specialize in electrical and mechanical engineering for public utilities and industry. Mr. Thompson is Chairman of the Memphis Section.

H. J. Randolph (A '36, M '48) has been named Sales Representative for southern California with the S and C Electric Company. His headquarters will be in Los Angeles. Designated to represent the company in a sales capacity in territory covering Oregon, Idaho, and western Montana is **C. E. Klaus** (A '33, M '43). He is located in Portland, Oreg.

T. F. Hadwin (A '35) has been appointed Superintendent of Substations and **Clarence Arnott** (A '27, M '43), Supervisor of Generating Stations, for the British Columbia Electric Railway Company, Limited, Vancouver, Canada. Mr. Hadwin has been with the firm since 1935, while Mr. Arnott is a 24-year veteran of the organization.

T. A. Phillips (A '37, M '47) has been promoted to the position of Chief Engineer for the Central Arizona Light and Power Company, Phoenix. Mr. Phillips joined the Engineering Department of the Arizona utility in 1936. Before his recent advancement, he had been Superintendent of Electric Distribution.

W. F. Wetmore (A '36, M '43) has been appointed Chief Electrical Engineer, Electrical Engineering Division, Engineering Department, Detroit (Mich.) Edison Company. Mr. Wetmore, who has been identified with the utility since 1928, previously served as System and Stations Engineer.

A. J. Mundt (M '43), formerly General Superintendent of Training and Personnel of the Western Union Telegraph Company, New York, N. Y., has been appointed Dean of Co-ordination at Walter Hervey Junior College in the same city. Dean Mundt retired from Western Union after twenty-seven years of service, both as an engineer and in personnel work.

T. E. Stieber (A '39) has been named Manager of the Westinghouse Electric Corporation's Central Station Division in the firm's Middle Atlantic District. Mr. Stieber has been with Westinghouse since 1925 when he joined the company in the Switchboard Service Department. He had been Manager of the General Mill Section, Philadelphia, Pa., since 1939.

C. A. Butcher (M '22, F '43) has been elected a Vice-President of the Elliott Company, Jeannette, Pa. Mr. Butcher will continue as General Manager of the Crocker-Wheeler Electric Manufacturing Company, Ampere, N. J., a recently acquired division of Elliott Company.

C. E. Woolgar (M '41) has been appointed Wire and Cable Manager of the General Sales Division of the Northern Electric Company Limited, Montreal, Quebec, Canada. Identified with the firm since 1939, he formerly was Sales Superintendent of the Wire and Cable Division.

Martin Montgomery (M '37) has been appointed Electrical Engineer for Industrial Electricians Limited, Vancouver, British Columbia, Canada. Recently, he had been Representative and District Manager for the English Electric Company of Canada, Limited, at Vancouver.

D. A. Battaglia (A '47) has been promoted to Assistant Professor of Electrical Engineering and **F. C. Powell** (A '32) has been advanced to Professor in the same department at the Drexel Institute of Technology, Philadelphia, Pa.

M. C. Thurling (M '43) has been appointed Manager of the Engineering Service Department of the Canadian General Electric Company. For the past 11 years, he had been Manager of the company's Montreal (Quebec) District of the Engineering Service Division.

John Gammell (A '38, M '35) Sales Representative in the Allis-Chalmers Manufacturing Company's Philadelphia (Pa.) district office, has been transferred to Milwaukee, Wis., as Supervisor of Sales Training. Mr. Gammell joined Allis-Chalmers in 1928.

OBITUARY • • • • • •

Francis Hodgkinson (A '02, Member for Life), designer and builder of steam turbines and Honorary Professor of Mechanical Engineering at Columbia University, New York, N. Y., died November 4, 1949, in Toledo, Ohio. Mr. Hodgkinson, who held 101 patents, principally on steam turbines, retired from his post as consulting mechanical engineer with the Westinghouse Electric and Manufacturing Company in 1936, after nearly 40 years with the firm. Born in London, England, June 16, 1867, he attended the Durham College of Science. From 1882 to 1885, he served an apprenticeship with Clayton and Shuttleworth, agricultural engineers, in Lincoln, England. In the latter year, he became associated with Sir Charles Parsons at Newcastle, England, in the early development of the reaction steam turbine. After a brief period of service with the Chilean navy, Mr. Hodgkinson, went to work for telephone and electric light companies at Lima, Peru. In 1894, he rejoined C. A. Parsons and Company, becoming Superintendent of the erecting and fitting shops. Two years later, when George Westinghouse negotiated a license agreement with Sir Charles Parsons, Mr. Hodgkinson, at the latter's recommendation, joined Westinghouse's firm to initiate the designing and construction of Parsons' steam turbines in the United States. He became Chief Engineer for Westinghouse in 1916 and consulting mechanical engineer ten years later, which post he held until his retirement. He served on the Iron and Steel Industry Committee, 1914–15, and the Power Generation Committee, 1924–28, and as principal United States delegate on the International Electrochemical Commission. Mr. Hodgkinson received the following honors: 1904, Silver Medal of the Louisiana Purchase Exposition; 1925, Elliott Cresson Gold Medal from the Franklin Institute of Philadelphia; 1931, Willans Gold Medal from the Institution of Mechanical Engineers and the Institution of Electrical Engineers of Great Britain; 1935, honorary degree of mechanical engineer from Stevens Institute of Technology; 1938, Holley Medal of the American Society of Mechanical Engineers; 1947, honorary membership in the American Society of Mechanical Engineers. He was a former Vice-President of the American Society of Mechanical Engineers and was made Chairman of its Committee on Power Test Codes in 1937. He was also a member of the Institution of Mechanical Engineers of Great Britain, Engineers Society of Western Pennsylvania, and Engineers' Club of New York.

Frank Baldwin Jewett (A '03, M '10, F '12, HM '45, Member for Life), former President of the National Academy of Sciences and a Past-President of AIEE, died November 18, 1949. A resident of Short Hills, N. J., Dr. Jewett was Vice-President in charge of development and research at the American Telephone and Telegraph Company for nearly 20 years (1925–44) and President of the Bell Telephone Laboratories, New York, N. Y., from 1925 to 1940. The distinguished scientist, who was a pioneer in the development of transcontinental telephony, had recently been named winner of the Hoover Medal for 1949 (*EE, Dec '49, p 1106*) and was slated to receive the award at the Winter General Meeting of the AIEE, which will be held January 30–February 4, 1950 in New York, N. Y. Another award presented to Dr. Jewett just prior to his death was the 1950 Medal of the Industrial Research Institute, Inc. A native of Pasadena, Calif., born September 5, 1879, the engineer was graduated from Throop Polytechnical Institute, now the California Institute of Technology, in 1898. He did advance study in electrical engineering under A. A. Michelson at the University of Chicago and then taught electrical engineering and physics at the Massachusetts Institute of Technology, Cambridge. He joined the American Telephone and Telegraph Company in 1904 and in 1912 was named Assistant Chief Engineer in the Western Electric Company. Four years later, he was named Chief Engineer. In 1925, he was elected a Vice-President of the American Telephone and Telegraph Company, a member of the Board of Directors of the Long Lines Department of that Company, and President of the Bell Laboratories. Dr. Jewett received a large number of honorary degrees and awards. Some of the latter include the Edison Medal (1928), the Faraday Medal (1935), the Washington Award (1938), and the Medal for Merit (1946). He held membership in the American Association for the Advancement of Science, the Institute of Radio Engineers, the American Physical Society, the Society for the Promotion of Engineering Education, and the Institution of Electrical Engineers (British). Some of the AIEE committees on which he served are: Edison Medal; Executive Medal; Protective Devices; Research; Standards; Engineering Foundation Board; Education; Hoover Medal Board of Award; Lamme Medal; and Co-operation with War Agencies.

Denney Warren Roper (A '93, M '13, F '14, Member for Life), identified for more than 30 years with the Commonwealth Edison Company, Chicago, Ill., died October 5, 1949, at his home in Carmel, Calif. Born October 18, 1869, in Grafton, Ill., Mr. Roper attended Washington University and later received his mechanical engineering degree from Cornell University in 1893. The following year, he enrolled in General Electric's student course at Schenectady,

N. Y. In 1897, he joined the Missouri Edison Electric Company, St. Louis, Mo., where he assumed the duties of Superintendent of Electric Equipment. From 1901 to 1903, Mr. Roper was engaged in consulting engineering work. In the latter year, he became affiliated with the Chicago (Ill.) Edison Company. In 1904, just before Chicago Edison was merged with the Commonwealth Electric Company to become the Commonwealth Edison Company, he was named to the post of Assistant to the Chief Operating Engineer, which position he continued to hold after the consolidation. For 18 years, 1915–33, Mr. Roper served as Superintendent of the Street Department, following which he was appointed Assistant Electrical Engineer in charge of the Research Division of the Engineering Department. Mr. Roper had been an active participant in AIEE affairs. Chairman of the Chicago Section in 1913, he later served on the following committees: Meetings and Papers; Protective Devices; Transmission and Distribution; and Research. He was a member of the United States National Committee of the International Electrotechnical Commission from 1923 to 1930. He served on the Committee on Electrical Insulation of the National Research Council and the American Committee on Electrolysis. Also, he was a member of the Western Society of Engineers. He won the latter society's Chanute Medal in 1907 and the AIEE Best Paper Prize in 1927.

Samuel Henry Blake (A '03, F '17, Member for Life), who retired in 1942 as general chairman of the General Electric Company's standardizing committees, died August 24, 1948, news of his death having belatedly been brought to the attention of the AIEE publications department. Born in Abington, Mass., July 25, 1872, Mr. Blake was graduated from the Massachusetts Institute of Technology in 1894. Subsequently, he worked for *Electrical World*, and later the International Arc Lamp Company, in New York, N. Y. In 1899, he entered the employ of the General Incandescent Arc Light Company in New York, and in 1903, he became an engineer in the Arc Lamp Department, being placed in charge of the Southside Works of the General Electric Company at Pittsfield, Mass. Ten years later, Mr. Blake was transferred to Schenectady, N. Y., as Engineer of the Supply Department. In 1923, he joined the staff of the Vice-President in Charge of Engineering. Mr. Blake became Chairman of both the General Electric Standardizing Committee and the Committee on Mechanical Design in 1927. For the next 15 years, he served as an arbiter in the settlement of technical problems and guided the preparation of the Standard Engineering Practice Letters, which formed the rules of the company's engineering procedure. In 1941, the Standardizing Committee was replaced by a number of separate product committees, with Mr. Blake remaining as general chairman. In addition to his other duties, he was a member of the Board of Directors of both the Warren Telechron Company, Ashland, Mass., and the General Electric X-Ray Corporation, Chicago, Ill., General Electric affiliates. He served on the Membership Committee, 1915–17, and the Standards Committee, 1928–38.

Asa White Kenney Billings (A '07, M '07, F '13, Life Member), who retired in 1947 as President of the Brazilian, Traction, Light, and Power Company, Rio de Janeiro, died November 3, 1949 in San Diego, Calif. Construction engineer for large hydroelectric developments in Spain, Mexico, and South America, Mr. Billings was born in Omaha, Nebr., in 1876. He was graduated from Harvard University in 1895, and received his master of arts degree the following year. Subsequently, he joined the Consolidated Traction Company in Pittsburgh, Pa. In 1899, he was employed by the Havana Electric Railway Company in Cuba as Assistant General Manager, later becoming Chief Engineer of that company and the Havana Central Railroad Company. From 1909 to 1911, he was Engineering Manager of J. G. White and Company, Inc., New York, N. Y., and thereafter went to Barcelona, Spain as Managing Director of the Ebro Irrigation and Power Company Limited. During World War I, he served as Lieutenant Commander in the United States Naval Reserve. Afterwards, he became a consulting engineer, first in Barcelona and then for the Canadian Engineering Company, New York, N. Y. In 1924, Mr. Billings was appointed Vice-President of the Brazilian Traction, Light, and Power Company, becoming President in 1945. The Brazilian government honored him in 1946 by presenting him with the National Order of the Southern Cross, in recognition of his development of hydroelectric resources in the São Paulo–Rio de Janeiro area. In 1947, he was made an honorary member of the American Society of Civil Engineers.

Charles Otto Collett (A '07, M '13, Member for Life), who retired as European Sales Manager, Westinghouse Electric International Company, in 1935, and a resident of Ewell, Surrey, England, died October 15, 1949. Born October 30, 1878, in Christiana, Norway, he received his electrical engineering degree from the Royal Institute of Technology in Hanover, Germany. Coming to the United States, he joined the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., in 1905. The following year, he taught electrical engineering at the State University of Missouri, in Columbia, Mo. Mr. Collett rejoined Westinghouse in 1907 as a member of the Railway Engineering Department. After helping to engineer the electrification of the New York, New Haven, and Hartford Railway, he worked in the General Engineering Department and, later, the Railway Sales Department. In 1914, he became associated with H. P. Taylor and Company, Pittsburgh, Pa. Three years later, he entered the employ of the Crucible Steel Company of America in Pittsburgh. He served in the Foreign Sales Department and, from 1919 to 1922, as Manager of the company's Japanese office. In the latter year, he became identified with the Westinghouse Electric International Company. During the next seven years, he worked in the company's New York, London, and Paris offices. He was named Managing Director in charge of business development and sales for the Westinghouse Electric Products, Inc., Paris, France, in 1929, and European Sales Manager for Westinghouse Electric International Company in 1935.

Frank L. Conrad (M '23), consulting engineer and former President of the United Light and Railways Company of Chicago, Ill., died October 22, 1949, at his home in Westport, Conn. Born in Cincinnati, Ohio, September 15, 1886, Mr. Conrad's early career was spent as a draftsman with utility and engineering concerns in the New York area. With Sanderson and Porter in New York City from 1908 to 1919, he served first as a draftsman, then as a designing engineer, and later as Executive Engineer in charge of field work. From 1915 to 1918, he was Chief Executive Engineer in the firm's Chicago, Ill., office, and during his last year with Sanderson and Porter, he served as Executive Engineer-Representative, directing the structural design of a 40,000-kw steam generating plant for the West Penn Power Company. In 1919, he was designated Chief Engineer for the firm of William G. Woolfolk, Chicago, Ill., later becoming a junior partner in the organization. Subsequently, he served as President of the Rochester (N. Y.) Ice and Cold Storage Utilities, Inc., this being the post he held before joining the United Light and Railways Company. He retired in 1948.

Charles Edward Brown, Jr., (A '40), Vice-President and General Sales Manager of the Okonite Company, Passaic, N. J., died November 8, 1949. He had been with Okonite for 14 years. Born August 2, 1894, in Buffalo, N. Y., Mr. Brown was an alumnus of Princeton University, having graduated in 1917 with a bachelor of arts degree. His first electrical experience was obtained with the Central Electric Company in Chicago, Ill., where he worked from 1919 to 1925. In his last year with the firm, he served as Country Sales Manager, supervising sales in 19 states. Mr. Brown was appointed Manager of the Power and Light Department of the Okonite Company in Chicago in 1925. Transferred to the company's offices in New York, N. Y., five years later, he was named Executive Assistant to the President. Going to Washington, D. C., in 1934, to help establish a sales office for Okonite, Mr. Brown in 1941 was designated Vice-President and in that capacity acted as Washington representative. In 1946, he moved to New York, N. Y., as Vice-President and Sales manager of the company. Mr. Brown was a member of the American Society of Naval Engineers.

T. Walker Cluff (M '37), Superintendent of Power, Generating Department, Ottawa Light Heat and Power Company, Ottawa, Ontario, Canada, died November 6, 1949. Born February 19, 1891, in Huntingdon, Quebec, he was educated at the Bliss Electrical School. In 1919, he joined Canadian Explosives Limited in Montreal, testing electric equipment, and two years later, was transferred to the company's Fabricoid plant at New Toronto, as Mechanical Superintendent. In 1923, he became associated with the Canadian Westinghouse Company, Hamilton, Ontario, where he directed the installation of electric equipment in power plants and distribution stations. He accepted an electrical engineering position with the Ottawa Electric Company and the Ottawa Electric Railway of the organization with whom the applicant is affiliated for reactor-trained personnel. Dr. F. G. Van der Lage, former Director of the training division of the Oak Ridge National Laboratory, has been named Director of the reactor training school.

Alfred Noble Prize Awarded to Fisher for Best Technical Paper

The Alfred Noble Prize for a technical paper of exceptional merit this year was awarded to John C. Fisher, Research Associate, General Electric Research Laboratory, Schenectady, N. Y., and a member of the American Society of Mechanical Engineers, for his outstanding research paper on "Anisotropic Plastic Flow."

This prize was established in 1929 and consists of an award from the income of a fund contributed by engineers and others in honor of the late Alfred Noble, Past-President of the American Society of Civil Engineers and of the Western Society of Engineers, for the purpose of perpetuating his name and achievements.

The award is made to a member of any grade of the AIEE, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, or the Western Society of Engineers, for a technical paper of exceptional merit accepted for publication in any of their technical publications, provided the author has not passed his thirty-first birthday at the time the paper is submitted. The award is based on papers published by each society within the 12 months preceding June 1 of each year. Papers prepared by joint authors are not eligible.

The amount of the prize, which is a cash award, and the contribution, if any, for payment of expense incurred by the recipient of the prize for transportation to and from the meeting at which the prize is awarded, is determined by resolution of the Board of Directors of the American Society of Civil Engineers. The award this year is approximately 350 dollars.

Langmuir Awarded Medal by French Engineering Society

Dr. Irving Langmuir, Associate Director of the General Electric Research Laboratory, Schenectady, N. Y., has become the second American scientist to receive the Mascart Medal. This is awarded triennially by the French electrical engineering society, the Société Française des Electriciens, to a scholar or engineer in any country "who is distinguished by an ensemble of works on pure or applied electricity."

The award to Dr. Langmuir, for the year 1948, was made at a dinner with Dr. C. G. Suits (F '47), General Electric Vice-President and Director of Research, presiding. The French organization had asked the AIEE to make the presentation; so it was given to Dr. Langmuir by H. L. Palmer (A '42) formerly Chairman of the local Section of the AIEE. He called attention to the important results that have come from Dr. Langmuir's researches.

One of Dr. Langmuir's most significant contributions to the electrical field was the gas-filled incandescent lamp, which greatly increased the efficiency of electric lighting. His pioneer work in electronics showed why early vacuum tubes could operate only at low power, and thus made possible the tubes of high power since used in powerful broadcasting stations and other applications. His chemical researches, which won him the Nobel Prize in Chemistry in 1932, included important studies of thin films made up of single layers of molecules.

He was also responsible for development of the method of welding with atomic hydrogen and a highly efficient screening smoke generator used by the armed services during World War II. Following the presentation, Dr. Langmuir spoke about some of his recent work in meteorology, a field in which Mascart was also interested.

Eleuthere E. N. Mascart, after whom the medal is named, was a famous French physicist who lived from 1837 to 1908. He was the founder of the Société Française des Electriciens, as well as of the French Central Laboratory and the High School of Electricity.

W. H. Aldridge Receives John Fritz Medal for 1950

According to a recent announcement by Louis S. Cates, Chairman of the John Fritz Medal Board of Award, the John Fritz Medal for 1950 has been awarded to Walter Hull Aldridge, President of the Texas Gulf Sulphur Company, who was cited "As Engineer of Mines and Statesman of Industry who by his rare technical and administrative skills has importantly augmented the mineral production of our country and Canada, and who by giving unselfishly of his wisdom and vision has guided his professional colleagues to higher achievements." The award was made at a special dinner held at the University Club in New York City under the auspices of the American Institute of Mining and Metallurgical Engineers, of which Mr. Aldridge is a member.

The John Fritz Medal was established in 1902 and is sponsored jointly by the four Founder Engineering Societies—American Society of Civil Engineers, the AIME, the American Society of Mechanical Engineers, and the AIEE—and awarded for scientific or industrial achievement in any field of pure or applied science. Former recipients have included George Westinghouse, Alexander Graham Bell, Orville Wright, Thomas A. Edison, Guglielmo Marconi, Herbert Hoover, Michael I. Pupin, and Charles F. Kettering.

Fabian Bachrach

Walter Hull Aldridge

Mr. Aldridge was born in Brooklyn, N. Y., on September 8, 1867, and he received his engineer of mines' degree from Columbia University in 1887. In 1929 he received an honorary degree of doctor of science from Columbia, and also its Egleston Medal. He is a former Trustee of Columbia University.

His professional career began in 1887 when he went to Pueblo, Colo., as assayer, chemist, and metallurgist at the Eilers Smelter. Five years later he was made manager of the United Smelting and Refining Company at Helena and Great Falls, Mont., and at the end of the next five years he was placed in charge of the exploration, mining, and metallurgical work of the Canadian Pacific Railroad, which included the development of the Sullivan Mine and the establishment of the Consolidated Mining and Smelting Company, Ltd.

In 1918, Mr. Aldridge was confronted with a new task: the United States was greatly concerned with its reserves of crude sulphur and the answer seemed to lie in the development of a commercial deposit at Big Hill, Tex. In March of that year, Mr. Aldridge became President of the Texas Gulf Sulphur Company, and although the war had terminated by the time sulphur could be produced, by opening new markets the company soon became foremost in its field.

ASME Confers National Awards at 70th Annual Meeting in N. Y.

Outstanding accomplishments in the fields of engineering, industrial management, and technical authorship were accorded recognition at the recent 70th Annual Meeting of The American Society of Mechanical Engineers held in New York, N. Y.

Cited for "distinguished achievement in industrial management as a service to the community" when he received the ASME's 1949 Henry Laurence Gantt Medal, was Arthur Clinton Spurr, President of the Monongahela Power Company, Fairmont, W. Va. Mr. Spurr was commended for having initiated and directed a program of rehabilitation in the Upper Monongahela Valley, which welded "the industrial, agricultural, and human resources of his community into a cohesive and dynamic force that has revitalized....the social and economic life of the entire area to which his influence extends."

The ASME Medal, highest honor of the society was conferred upon Fred L. Dornbrook, General Consultant, Power Plant Department, Wisconsin Electric Company, Milwaukee, for "outstanding engineering in the research, design, and operation of pulverized fuel combustion equipment." He was credited with having pioneered in the development of pulverized coal-fired power-generating plants.

Fred B. Seely, Head of the Department of Theoretical and Applied Mechanics at the University of Illinois, Urbana, was awarded the Worcester Reed Warner Medal for "outstanding contributions to permanent engineering literature...his authoritative text books on mechanics" having "a profound influence on the development of young engineers for more than 25 years."

Recipient of the Melville Prize Medal for "the best original paper or thesis on any mechanical engineering subject presented before the ASME the previous year" was Harold B. Maynard, founder and President of the Methods Engineering Council, Pittsburgh. A Past-President of the American Society for the Advancement of Management, Mr. Maynard's paper was "The Role of Scientific Management in Industrial Recovery."

The Richards Memorial Award for "outstanding achievement in mechanical engineering within 20 to 25 years after graduation" went to Arthur M. Wahl of the Westinghouse Research Laboratories, Pittsburgh, Pa. Phillip S. Myers was designated winner of the Pi Tau Sigma Gold Medal for "outstanding achievement in mechanical engineering within ten years after graduation." Mr. Myers is Assistant Professor of Mechanical Engineering at the University of Wisconsin, Madison.

Olson Receives Audio Award. Dr. Harry F. Olson, Director of the Acoustical Research Laboratory of the Radio Corporation of America Laboratories, Princeton, N. J., has received the first John H. Potts Memorial Award from the Audio Engineering Society. Dr. Olson was given the award "for outstanding accomplishments in the field of audio engineering." The medal is named for the late editor of *Audio Engineering Magazine*. The RCA scientist pioneered in the development of directional microphones, now almost universally used in radiobroadcasting, sound motion pictures, and television. He has been with RCA since 1928.

Future Meetings of Other Societies

American Meteorological Society. 30th Anniversary Meeting. January 3–6, 1950, St. Louis, Mo.

American Society of Mechanical Engineers–Society for the Advancement of Management. Plant Maintenance Show. January 16–19, 1950, The Auditorium, Cleveland, Ohio

American Society for Testing Materials. February 27–March 2, 1950, William Penn Hotel, Pittsburgh, Pa.

Armed Forces Communications Association. 1950 Annual Meeting. May 12, 1950, New York, N. Y.; May 13, 1950, Fort Monmouth, N. J.

Atomic Energy Commission–New York University. Conference on Industrial and Safety Problems of Nuclear Technology. January 10–12, 1930, New York University, New York, N. Y.

Institute of the Aeronautical Sciences. 18th Annual Meeting. January 23–26, 1950, Hotel Astor, New York, N. Y.

Midwest Power Conference. April 5–7, 1950, Sherman Hotel, Chicago, Ill.

National Electrical Manufacturers Association. March 13–16, 1950, Edgewater Beach Hotel, Chicago, Ill.

National Petroleum Association. April 12–14, 1950, Hotel Cleveland, Cleveland, Ohio

Protective Relay Engineers. Third Annual Conference. March 20–22, 1950, Department of Electrical Engineering, Agricultural and Mechanical College of Texas, College Station, Tex.

Society of Automotive Engineers. January 9–13, 1950, Hotel Book-Cadillac, Detroit, Mich.

Society of Plastics Engineers. Sixth Annual National Technical Conference. January 11–13, 1950, Hotel Carter, Cleveland, Ohio

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TV Cabinets Molded by Hydraulic Press

Plastic television cabinets are shaped by this giant hydraulic press, which exerts a force of 3,000 tons. Using this machine together with a smaller press, the Molded Products Corporation claims it can turn out four cabinets every ten minutes. Molding procedure for the press, built by the Hydraulic Press Manufacturing Company, is as follows: Preheating brings Phenolic bricks up to molding temperature. Bricks are placed in the bottom of the mold. Plunger descends, softening preforms, and forcing them into mold. Mold is fully closed and 3-minute baking cycle occurs. Plunger and finished cabinet are extracted from mold cavity

NRC Committee Recommends Redefining Radioactive Units

A joint committee of the Divisions of Chemistry and Chemical Technology and of Mathematical and Physical Sciences of the National Research Council, which was appointed in 1947 to study standards and units of radioactivity, has unanimously adopted three recommendations with respect to radioactive units. One of these proposals would effectively divorce the curie from the disintegration rate of radium by assigning to the former an arbitary magnitude (3.7×10^{10} disintegrations per second) approximately equal to the disintegration rate of radium. This arbitrary figure is therefore not influenced by any future revisions of the generally accepted disintegration rate of radium. This recommendation has been submitted to the Joint Commission on Standards, Units, and Constants of Radioactivity of the International Unions of Chemistry and Physics for the purpose of obtaining international agreement.

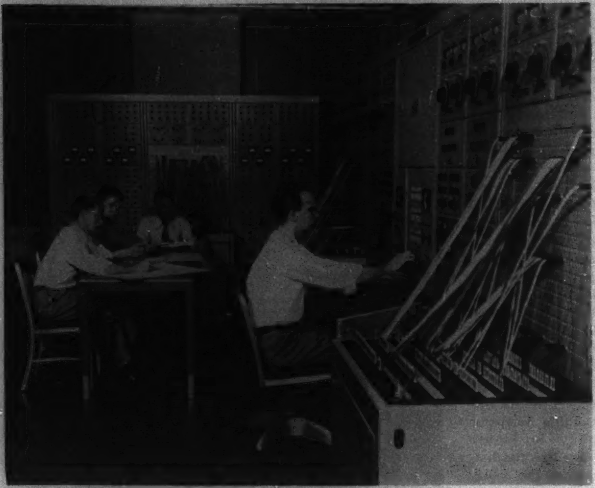
This changes, slightly, the meaning of the curie when applied to radium. For example, one curie of radon is no longer, on the basis of these recommendations, the amount in equilibrium with one gram of radium, but is the amount undergoing 3.7×10^{10} disintegrations per second. Similarly, one milligram and one millicurie of radium are no longer rigorously synonymous. This distinction has a number of precedents in physics; for example the international ampere, now abolished, was not quite equal to the absolute ampere and the angstrom unit is nearly, but not quite, equal to 1,000 *x*-units.

A second recommendation suggests that the rutherford be defined as that quantity of any radioactive species (radioisotope) undergoing 10^6 disintegrations per second.

Thirdly, for the quantitative comparison of radioactive sources emitting gamma rays, for which disintegration rates cannot be determined, the "roentgen per hour at one meter" (rhm) is recommended. This essentially would not be a new unit since all units involved are well established, explicitly defined, and are in common usage.

The recommendation of this latter unit is a practical step to insure that, by its use, gamma-ray measurements are so made with instruments and under such conditions that measurements on a given isotope (nuclear species) made in any laboratory will be directly comparable with similar measurements made in other laboratories. This will result, if the procedures used comply with the definition of the unit; that is, a source is one rhm if it produces one roentgen per hour at a distance of one meter.

A-C Analyzer Solves Network Problems



Sitting at the controls of this General Electric a-c network analyzer, the engineer is setting up a miniature model of a power transmission network. Comprising four plug-and-jack boards similar to those used by telephone operators, the analyzer contains myriad small generators and lines which can be used to simulate an actual power network. By plugging in the analyzer's lines, the engineer can easily determine what would happen in a power system if new lines are added or sources of power changed

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Station WWV Has New Signal for Radio Propagation Disturbances

Effective November 1, 1949, a new broadcast signal of the National Bureau of Standards radio station *WWV* was incorporated in the technical radio broadcast services of the Bureau's Central Radio Propagation Laboratory. This signal, a warning of unstable conditions in the ionosphere, provides additional data on ionospheric disturbances—information of vital significance to the armed services and the communications industry in maintaining uninterrupted long-distance radio communications.

Heretofore, two grades of propagation conditions have been recognized in the notices given at 19 and 49 minutes past each hour by station *WWV*, which continuously broadcasts standard radio frequencies, time announcements, and the standard musical pitch in addition to the radio propagation disturbance notices. The letter *N* (in International Morse Code) repeated several times has signified normal conditions, whereas the letter *W* has constituted a warning that disturbed conditions were present or expected within 12 hours. A third category, indicating unstable conditions and denoted by the letter *U*, will now be used when the forecasters at the warning center expect satisfactory reception of short-wave communication or broadcast services employing high-power transmitting equipment operating on the recommended frequency, but poor results on less well equipped services. Such conditions often occur as major disturbances subside. Although point-to-point communication links are able to resume reliable operation, mobile services and short-wave broadcasts continue to experience difficulty. The propagation disturbance notices, broadcast in International Morse Code, primarily refer to the North Atlantic Radio circuits.

Commonwealth & Southern Reorganization Completed

Organization of Commonwealth Services Inc., formerly The Commonwealth and Southern Corporation of New York, as well as organization of a wholly owned engineering subsidiary, Commonwealth Associates Inc., has been completed, according to a recent announcement.

The service company, which was formerly owned by the operating companies in the Commonwealth system, with its services limited to these companies, is now established as an independent company, authorized to conduct business in public utility, industrial, and other fields. Offices are located in New York and Jackson, Mich., the latter city being the headquarters of the engineering organization.

The stock of the company is owned by its officers and employees, numbering about 400 people. The company and its predecessors have a business history of more than 40 years.

The company has handled more than a billion dollars of financing work over the past 15 years and its engineering forces have designed more than 1,400,000 kw in electric generating plant capacities since 1930. Services offered by the Commonwealth organization include financing, engineering, accounting, taxes, insurance, pensions and welfare plans, rates and rate audits, purchasing, merchandising, public relations, stock transfer, and general consultation and reports.

Officers, who are also the directors of Commonwealth Services Inc., are: Granville H. Bourne, President; William G. Bourne, Jr., Vice-President and Treasurer; William B. Tippy, Vice-President; J. H. Foote (F '32), Vice-President; Walter J. Herrman, Vice-President; Harold S. King, Comptroller; and Edward E. Nelson, Secretary.

Officers of the new engineering organization are: J. H. Foote, President; George C. Daniels and J. R. North (F '41), Vice-Presidents; Edward J. Dissmeyer (F '47), Secretary; and Russell W. Parkinson, Treasurer, all of Jackson, Mich. (See page 83 of this issue).

R. F. Guy Named President in Annual IRE Election of Officers

Raymond F. Guy, Manager of Radio and Allocations Engineering for the National Broadcasting Company, and Sir Robert Watson-Watt, Governing Director of Sir Robert Watson-Watt and Partners, Limited, of London, England, have been elected President and Vice-President, respectively, of The Institute of Radio Engineers for 1950.

Mr. Guy joined the staff of *WJZ*, in New York, in 1921 when it began operations as the world's second licensed broadcasting station. Sir Robert, who received the IRE Fellow Award in 1947, for "his early contributions to radio and his pioneering work in radar," is considered England's outstanding radar authority.

Candidates elected as Directors-at-Large for the 1950–1951 term are: William R. Hewlett, Vice-President of Hewlett Packard Company of Palo Alto, Calif., and James W. McRae, Director of Electronic and Television Research of Bell Telephone Laboratories, Inc., Murray Hill, N. J.

The election of Regional Directors for 1950–1951 is announced as follows: North Atlantic Region, Professor Herbert J. Reich of the Electrical Engineering Department, Dunham Laboratory, Yale University; Central Atlantic Region, Professor Ferdinand Hamburger, Jr., of the School of Engineering, Johns Hopkins University, Baltimore, Md.; Central Region, John D. Reid, Manager of Research of Crosley Division of Avco Manufacturing Corporation, Cincinnati, Ohio; Pacific Region, Professor Austin Eastman, head of Department of Electrical Engineering of the University of Washington, Seattle.

Associated with the National Broadcasting Company since 1929, Mr. Guy has participated in numerous international conferences on radio in Havana, Mexico City, Montreal, and Washington. Sir Robert has been Deputy Chairman of the Radio Board of the British Cabinet and Scientific Advisor on Telecommunications for the Air Ministry.

Fraser Elected President of AWS. The American Welding Society has elected O. B. J. Fraser, Assistant Manager, Development and Research Division, The International Nickel Company, Inc., New York, N. Y., as its President for the year 1949–50. Mr. Fraser joined The International Nickel Company in July 1917 as metallurgical engineer at the Bayonne, N. J., works. In 1918, he was transferred to the Port Colborne, Ontario, Canada, works and became successively superintendent of the Electrostatic Fume Precipitation Plant, night works superintendent, and research engineer. During 1922, while still with the company, he became associated with the Mellon Institute in the study of corrosion of nickel and nickel alloys. Mr. Fraser was placed in charge of the Research Laboratories of International Nickel at Bayonne in 1924, remaining in that position until 1932. During the next two years he carried on field development work in the use of nickel alloys in the petroleum industry. Mr. Fraser served as National Treasurer of the American Welding Society (1941–47), Second Vice-President (1947–48), First Vice-President (1948–49).

Williams, Patch, Awarded Medals. Roy B. Williams, Assistant District Manager and Orin G. Patch, Chief Concrete Engineer of the Bureau of Reclamation's Columbia River District at Coulee Dam in Washington, have been awarded the Department of the Interior Gold Medal and Distinguished Service Certificate for superior contributions to the advancement of the nation's vast multipurpose water conservation program in the West. Mr. Patch terminated more than 28 years of Federal service at the age of 70, on September 30; Mr. Williams retired on October 28, at the age of 61, after more than 37 years of active duty. Mr. Patch has been closely associated with the development of the arts of concrete control and placement since 1927. He was extremely active in the development of ideas, methods, processes, and equipment for the improvement of concrete and its products and directed concrete work for the Kittitas Division of the Yakima project, on the Hoover Dam, and on the Coulee Dam. Mr. Williams also served on the Kittitas Division of the Yakima Project, as well as on the Milk River and Sun River projects, the Columbia Basin, the Boulder Canyon, and the Central Valley projects.

Alcoa Tries New Core for ASCR. A short transmission line employing steel-reinforced aluminum cable with an aluminum-coated steel core wire instead of the usual zinc-galvanized core was put into operation by Aluminum Company of America in May 1949, as part of the expansion of the testing facilities of its electrical research division. The line, operating at 460 volts, consists of approximately 2,800 feet of number 4 steel-reinforced aluminum cable 6/1. Research has indicated that aluminum-coated steel may be superior to zinc-galvanized wire for this particular purpose. Alcoa has been doing developmental work on aluminum-coated steel wire for some time. The small amount used in this installation was fabricated solely for experimental purposes and without conforming to tensile specifications.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Transmission Line Charts

To the Editor:

The stated objective of H. L. Krauss' article "Transmission Line Charts" (*EE, Sep '49, pp 767–74*), is to present "for the benefit of persons not familiar with the charts and their applications, and for those who may have used the charts without knowing the theory involved, the development and some applications—*with the mathematics simplified as much as possible*" (page 767; my italics). This seems to be hardly the case. It is the more regrettable since the type of reader to whom the article is addressed is likely to accept the exposition to be as straightforward and to the point as possible, and will probably be more dismayed than ever in trying to understand the basic theory of the transmission line circle diagrams.

This type of diagram is a plot of the input impedance as a function of load impedance and transmission angle, in terms of auxiliary co-ordinates. Only impedance concepts are involved. In that case why introduce equations 3 through 7, 9, and 10 concerning incident and reflected voltage and current waves which do not contribute to the derivations of the diagrams? In spite of these numerous equations, expression 8, which is the basis of the circle diagram, is stated as a definition and is not derived.

Let us see whether a more compact and coherent alternative is not available: Form the traction K_S (because of its physical significance known as the "reflection coefficient"):

$$K_S=\frac{\mathcal{Z}_S-\mathcal{Z}_o}{\mathcal{Z}_S+\mathcal{Z}_o}$$

Substitute for $\mathcal{Z}_S$ from the fundamental impedance equation 1 (Mr. Krauss' numbering and symbols adhered to; my equations designated by Roman numerals):

$$\mathcal{Z}_S=\mathcal{Z}_o\frac{\mathcal{Z}_R+\mathcal{Z}_o\tanh\gamma S}{\mathcal{Z}_o+\mathcal{Z}_R\tanh\gamma S} \tag{1}$$

to obtain immediately

$$\frac{\mathcal{Z}_S-\mathcal{Z}_o}{\mathcal{Z}_S+\mathcal{Z}_o}=\frac{\mathcal{Z}_R-\mathcal{Z}_o}{\mathcal{Z}_R+\mathcal{Z}_o}\cdot\frac{1-\tanh\gamma S}{1+\tanh\gamma S}=\frac{\mathcal{Z}_R-\mathcal{Z}_o}{\mathcal{Z}_R+\mathcal{Z}_o}\epsilon^{-2\gamma S} \tag{I}$$

which is postulated as a "definition" (sic) by equation 8 in the form of

$$K_S=K\epsilon^{-2\gamma S} \tag{8}$$

Equation I is sufficient for the derivation of the rectangular transmission chart and, in addition, provides a clear picture of its basis.

Consider, for a fixed value of $|K|=k$:

$$\frac{|\mathcal{Z}-\mathcal{Z}_o|}{|\mathcal{Z}+\mathcal{Z}_o|}=k \tag{II}$$

where $\mathcal{Z}$ is $\mathcal{Z}_R$ or $\mathcal{Z}_S$.

From elementary plane geometry it is known that the locus of all points $\mathcal{Z}$ which divide the distances from two fixed points, that is, $\mathcal{Z}_o$ and $(-\mathcal{Z}_o)$, in a fixed ratio is a circle (circle of Appolonius). Radius and center dimensions of the circle follow directly from the geometry of Figure 1 by applying equation II to points P_1 and P_2. This is equivalent to equation 13 through 16. It can be concluded from equation I that a load impedance lying on a circle for $k=k_R$ results in an input impedance situated somewhere on the circle of the same family with $k_S=k_R\epsilon-2\alpha S$.

To obtain the second co-ordinate, consider K when its phase angle has a fixed value:

$$\sphericalangle\left(\frac{\mathcal{Z}-\mathcal{Z}_o}{\mathcal{Z}+\mathcal{Z}_o}\right)=\sphericalangle(\mathcal{Z}-\mathcal{Z}_o)-\sphericalangle(\mathcal{Z}+\mathcal{Z}_o)$$
$$=\text{constant}$$

In words, this means that the $\sphericalangle(-\mathcal{Z}_o).\text{-}\mathcal{Z}.\mathcal{Z}_o$, that is α in Figure 2, remains constant for all possible positions of $\mathcal{Z}$. Again from elementary geometry, the locus of all points in the plane that fulfill this condition is a circle passing through $\mathcal{Z}_o$ and $(-\mathcal{Z}_o)$. The radius and center dimensions are evident from the geometry of Figure 2. This bit of geometric intuition eliminates the need for equations 17 through 21 which even so could have been simplified by taking tangents in equation 17 and applying the summation formula directly.

This completes a unified derivation of the rectangular chart. Now for the Smith chart treated from page 770 on of the article under consideration.

Equations 9a, 10a, 26, 27 are completely redundant since their result (equation 27a) is merely equation 11 in rationalized form, with $K_S=|K_S|\epsilon^{j\phi S}$ from equation 8 of the article.

The author states, on page 770, left column that "The conversion of the first form of chart to the second may be made by means of a conformal transformation, but in this article the Smith chart will be developed independently from the line relationships given in a foregoing section." The latter part of the statement has just been demolished; obviously the two charts cannot be independent of each other if "The Smith chart shown in Figure 11 represents the same information as the chart of Figure 3" (ibid.), that is, the rectangular chart. As for the point concerning the question of a conformal transformation the author does not seem to realize that equation 30 as applied to equations 28 and 29 and leading to equations 31 and 32 represents just that. Specifically, the conformal transformation

$$|K_S|\epsilon^{j\phi S}=K_S=u+jv \tag{30}$$

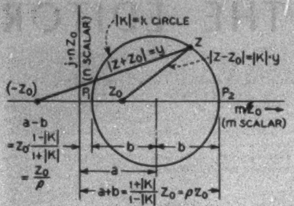


Figure 1. The family of circles: |**K**| = constant

is being applied to

$$\frac{Z_S}{Z_o}=r_1+jx_1=\frac{1+K_S}{1-K_S} \tag{11}$$

in its rationalized form of equations 28 and 29.

As far as "Conclusion" on page 774 is concerned, it should be realized that the diagrams are not restricted to systems characterized by standing waves but apply to any linear, symmetrical network composed of resistors, inductors, and capacitors. As a matter of fact, our method of derivation allows the immediate extension to unsymmetrical networks. The form of the charts remains unaltered but iteration parameters replace image parameters; alternately, the two image impedances Z_{o1} and Z_{o2} can be used provided load impedance is normalized with respect to Z_{o2} and input impedance with respect to Z_{o1}.

After all, the existence of these transmission charts is due to the fact that cross-ratio of four elements is invariant under the transformation

$$Z_{in}=\frac{AZ_L+B}{CZ_L+D}$$

so that circles are transformed into circles. Any linear physical system (lumped-constants networks, or transmission lines, stubs, cavities, and so forth) that transforms impedance according to this equation can be represented by these circle diagrams. The reflection coefficient amounts only to an alternate expression of impedance in terms of a base impedance which is transformed by the system into itself.

A tutorial article such as Mr. Krauss has prepared, which does not raise any claim to originality of material, is justified if the method of presentation is particularly lucid and clear-cut, which makes it superior to other available expositions of the subject. The article under discussion may have fallen short of these goals.

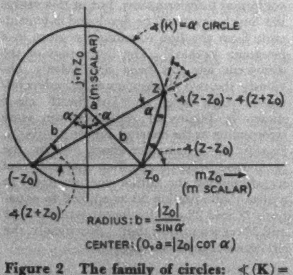


Figure 2 The family of circles: ∢(**K**) = constant

LEO STORCH

(Radio Corporation of America, RCA Victor Division, Camden, N. J.)

Electrical Essays

To the Editor:

Electromagnetic Induction Intensifier. I was pleased to hear from my old friend A. B. Reynders (*EE, Nov '49, p 1017*). Perhaps if we could get together over a bottle of wine as at our last meeting in Bergamo, Italy, in 1938, our technical differences would be very pleasantly resolved. It shocks Mr. Reynders, as it has shocked many other of my friends, to learn that generally lines of magnetic force do not form simple closed curves. This may be taken as an experimentally verifiable fact.

The magnetic intensity or force at any point in space in the neighborhood of current-carrying conductors is experimentally determinable, and may be calculated by well-known methods based on experiment. Thus at each point in space we have a unique direction, the direction of the magnetic force, which we, Mr. Reynders and all others, must agree upon and accept as given by experiment.

Now a line of force is defined as a curve in space having at each of its points the same direction as the magnetic force. Hence, in tracing out a line of force, we have no choice or latitude. Having started on such a line, we must follow wherever the direction of the magnetic force at each point of space leads us. We then meet the real hard indisputable empirical fact that the lines of force generally do not close, but spiral around endlessly.

In my Alter Ego's intensifier, the circuits were chosen so as to make this fact evident. Once having accepted this possibility that lines of force may not close, we soon become convinced that this must be the general case, and that only under very special conditions, as for example for a coil of perfect planar symmetry, do the lines of force close. I agree with Mr. Reynders that the invention of my Alter Ego will not work.

John A. Moody makes a great contribution (*EE, Nov '49, p 1018*) to the theory of the electromagnetic induction intensifier. His discovery that the less use which is made of the intensifier coil, the greater is its effectiveness, is most extraordinary. I shall hasten to disclose to my Alter Ego this amazing property of his invention.

Space Charge Theory Exploded. Paul Reichel (*EE, Nov '49, p 1018*) very ably explains the role of space charge in limiting emission in a thermionic tube. His one sentence, "Thus, while an electron that has left the filament is not repelled back by the space charge, this space charge causes the filament to produce a lesser force on the electron," tells the story about as well as possible.

Magnetic Speedometer. N. Kerruish (*EE, Nov '49, p 1018*) is quite right in calling me to task for speaking of a nonzero electromotive force along a conducting rod at rest in an electric field. I surmise that, like myself, he takes for the definition of the electromotive force over a specified path from one point to another, the integral along that path of the electric force, *E*. In the case of the highly conducting rod at rest, *E* along it is necessarily zero, and therefore the electromotive force along it is also zero.

For a rod moving in a magnetic field, however, *E* is not zero along the rod, and therefore the electromotive force along the rod is also not zero.

The point of my essay was of course that the observer is unable to determine whether the charges which he finds at the ends of the rod are to be accounted for by the rod being at rest in an electric field, or by the rod moving in a magnetic field. Mr. Kerruish agrees with me in this analysis.

In extenuation, I may note that I did enclose the incorrectly used term, electromotive force, in quotation marks.

J. SLEPIAN (F '27)

(Associate Director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Trends in Fluorescent Lamps

To the Editor:

The article, "Trends in Fluorescent Lamps," by Willard C. Brown (*EE, Oct '49, pp 857–60*) did not fully describe the properties of the cold cathode fluorescent lamp. The author made his point when he said, "I can confuse you more thoroughly by mentioning that the lamp with the cold cathode actually feels hotter at the ends than the lamp with the hot cathode."

According to a paper given at the last convention of the Illuminating Engineering Society by an engineer from The General Electric Company, the life of cold cathode lamps tested in the same manner as the hot cathode type is in the order of 25,000 hours of service and, as stated in this same paper, the light output does not keep getting dimmer and dimmer until the point where the user just *cannot* afford to keep them going.

Test results and experience gained from installations indicate that the maintained light at the end of 10,000 hours is 79 per cent of the initial light output. At the end of 20,000 hours the light output is greater than 60 per cent of the initial value. Other advantages which are inherent in the cold cathode lamp are: the lamp can be dimmed over a wide range of values; the cold cathode lamp is an efficient, low brightness source; the lamp is an instant starting type and its life is not affected by continuous starts. Advantages of the manufacturing method inherent in cold cathode are that lamps can be obtained in regular fluorescent lamp colors and in a wide range of custom colors. Standard cold cathode lamps, made in accordance with American Standards Association specifications, can be obtained from a number of manufacturers. Cold cathode lamps can also be custom made in any size and color to suit any particular purpose.

Cold cathode lamps are generally installed in any one of two ways. In a series arrangement, one large transformer serves up to 12 8-foot lamps, connected to one circuit. The other arrangement with the use of a ballast for operating one or two lamps is similar to the method used with hot cathode fluorescent lamps.

ROBERT CUTLER

(President, Fluorescent Lighting Association, New York, N. Y.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

AMERICAN UNIVERSITIES AND COLLEGES. Edited by A. J. Brumbaugh and M. Irwin. Fifth edition. American Council on Education, Washington, D. C., 1948. 1,054 pages, $9^3/_4$ by $6^1/_2$ inches, cloth, $8. Including the latest information, this book is an authoritative guide to accredited institutions of higher learning in the United States and its territories. In Part I, there are concise but comprehensive descriptions of various aspects of American higher education. Part II supplies pertinent information about 820 accredited institutions. In the appendixes, some further general and statistical data are given.

BASIC ENGINEERING SCIENCES, Solution to Problems, Part II, Professional Engineer Examinations, New York State. By W. Glendinning, 5123 Bell Boulevard, Bayside, N. Y., 1948. 60 pages, 11 by $8^1/_2$ inches, paper, $3. Useful to those preparing for Part II and Part III of the examinations for the license of Professional Engineer in New York State, this book presents questions and solutions to the problems of past examinations in practical application of basic engineering sciences. The major topics covered are hydraulics, mechanics and machine design, thermodynamics, and electrical principles and equipment.

CHAMBERS'S SIX-FIGURE MATHEMATICAL TABLES, 2 volumes. Volume I. Logarithmic Values. Volume II. Natural Values. By L. J. Comrie. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England, 1949. 576 pages each, tables, $10^1/_4$ by 7 inches, cloth, $10 each ($17.50 per set). Volume I of this set provides tables of logarithmic values as follows: of numbers up to 100,000 in various ranges and intervals; of trigonometrical functions of angles in degrees, minutes and seconds; of angle functions in degrees and decimals and in radians; of hyperbolic and gamma functions. Volume II provides tables of natural values for: trigonometrical functions of angles in degrees, minutes and seconds; angle functions in degrees and decimals; circular functions (argument in radians); exponential and hyperbolic functions; also natural logarithms, powers, roots, reciprocals, factors, prime numbers, and so forth.

ELECTRIC AND MAGNETIC FIELDS. By S. S. Attwood. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 475 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5.50. Provides a smooth transition from the study of mathematics, mechanics, and physics to advanced electrical engineering. In this edition, the material on the magnetostatic field is rewritten to emphasize current rather than magnetic poles as the source of the magnetic effect. The sections on magnetic materials have been improved, and an elementary discussion added on dia-, para-, and ferromagnetism. In line with recent trends, the formulas throughout the book have been recast in the rationalized form of the MKS system.

ELECTRON TUBES, 2 volumes: Volume 1, 1935–1941; Volume 2, 1942–1948. Edited by A. N. Goldsmith and others, published by *RCA Review*, Radio Corporation of America, RCA Laboratories Division, Princeton, N. J., March 1949. Volume 1, 475 pages, volume 2, 454 pages, illustrations, diagrams, charts, tables, 9 by 6 inches, cloth, $2.50 each volume plus $0.20 foreign postage. This 2-volume set presents 40 selected papers reprinted from leading journals, together with some 50 additional summaries. Each volume is divided into four sections: general; transmitting; receiving; and special. The appendixes contain a further bibliography on vacuum tubes, thermionics, and related subjects by RCA authors. A reference list of pertinent RCA Application Notes is also included.

ELEKTRISCHE FERNMELDEEINRICHTUNGEN IM GRUBENBETRIEB. By J. Busch and W. Gassmann. Second edition. Verlag Glückauf, Essen, Germany, 1949. 143 pages, illustrations, diagrams, charts, tables, $8^1/_4$ by 6 inches, cloth, 23 DM bound, 15 DM paper. Dealing with electric communication systems in mines, this book is of interest to those who plan such systems as well as those who construct and operate them. Divided into two parts, part one considers signal systems, and part two mine telephone systems. There are over 70 plates, and the appendix contains useful tables of abbreviations and symbols.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th Street, New York 18, N. Y.

ÉTUDE ÉLECTROMAGNÉTIQUE GÉNÉRALE DES MACHINES ÉLECTRIQUES. By R. Langlois Berthelot. Editions Eyrolles, 61 Boulevard Saint-Germain, Paris (Ve), France, 1949. 284 pages, illustrations, diagrams, tables, $9^1/_2$ by $6^1/_4$ inches, 1,600 frs. Written for college students and semiprofessionals in industry, this first volume of a 4-volume set considers the general structure and operation of electromagnetic machines. It is divided into four sections: The "families" of electric machines, electric and magnetic circuits, devices with armature cores, and machines with rotational symmetry.

GIORGIS RATIONALES MKS-MASSSYSTEM MIT DIMENSIONSKOHÄRENZ. By E. Bodea. Second edition. Verlag Birkhäuser, Basel, Switzerland, 1949. 142 pages, tables, $9^1/_2$ by $6^1/_2$ inches, paper, 24.50 Swiss frs. This book discusses the MKS system. It has four main parts: a review of the development of the physical and technical systems of measurement; an explanation of the properties and practical advantages of the Georgi system; a discussion of the theoretical principles of all dimension and unit systems; and an enlargement of the MKS system. It concludes with 17 tables of dimensions, units, and conversion factors.

MATHEMATICS OF CIRCUIT ANALYSIS, EXTENSIONS TO THE MATHEMATICAL TRAINING OF ELECTRICAL ENGINEERS. (Principles of Electrical Engineering Series). By C. A. Guillemin. Technology Press, Massachusetts Institute of Technology; John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1949. 590 pages, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $7.50. This volume contains a collection of a variety of principles and methods essential to a thorough understanding of electric network theory. The first four chapters bring together topics in advanced algebra. The following chapter on Vector analysis precedes the discussion of functions of a complex variable. The last chapter is concerned with Fourier series and integrals.

POWER CAPACITORS. By R. E. Marbury. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 205 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches cloth, $3.50. Of value to both engineers and those with little technical background, this book covers the fundamental working principles, materials used in the manufacture, and the characteristics of completed units of power capacitors. It traces the history and development of capacitors and their applications to power systems. It provides an abundance of detailed data about the installation and maintenance of capacitors, new developments, and accessories.

PROFESSIONAL REGISTRATION LAWS AND THE ENGINEER. (A Study of Engineering Registration Laws). By A. M. Sargent, author and publisher, 19669 John R St., Detroit 3, Mich., 1948. 60 pages, illustrations, $8^1/_2$ by $5^1/_2$ inches, paper, $0.75. Of interest to the engineering profession, this pamphlet discusses engineering licensing laws in the various states and their effects on engineers and engineering.

RADIO AND TELEVISION MATHEMATICS. By B. Fischer. Macmillan Company, New York, N. Y., 1949. 484 pages, diagrams, charts, tables, $8^1/_4$ by $5^1/_2$ inches, cloth, $6. This practical handbook and reference gives the solutions for nearly 400 problems typical of those encountered in the construction, operation, and servicing of radios, television, and other electronic equipment. The problems are arranged conveniently under electronic headings with the setup and step-by-step solution given. Two sections of formulas, mathematical tables, the *J*-operator, powers of ten, polar vectors, and other data are also included.

INGENIEUR-TABELLEN, ZAHLENTAFELN UND FORMELN FÜR STUDIUM UND PRAXIS. By T. Ricken. Carl Hanser Verlag, Munich, Germany, 1949. 292 pages, diagrams, tables, $7^3/_4$ by $5^1/_2$ inches, stiff cardboard, 9.50 DM; half linen, 11 DM. This comprehensive book of tables contains important numerical values for a wide range of engineering work. The use of the tables is facilitated by precise definitions and explanations. Arithmetical examples and technical formulas supplement the numerical tables. A detailed subject index is an aid to rapid consultation.

APPLICATIONS PHYSIQUES DE LA TRANSFORMATION DE LAPLACE. (B. MÉTHODES DE CALCUL I). By M. Parodi. C.N.R.S. Éditeur (Centre National de la Recherche Scientifique), 1948; Dépositaire: Gauthier-Villars, 55 quaides Grands-Augustins, Paris (6e), France, 177 pages, diagrams, tables, $9^1/_2$ by 6 inches, paper, 800 frs. Of interest to physicist and engineers, this book considers practical applications of the Laplace transformation and the symbolic calculus to the solution of differential equations, partial differential equations, definite integrals, and integral and integral-differential equations. The relationships of the symbolic calculus to the theory of Volterra and to electric networks are discussed.

BASIC ELECTRICAL ENGINEERING FOR STUDENTS OF ELECTRICAL ENGINEERING. By G. F. Corcoran. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1949. 449 pages, illustration, diagrams, charts, tables, $9^1/_4$ by $5^3/_4$ inches, cloth, $4.50. This textbook was designed especially for use in an introductory course in electrical engineering. The most outstanding feature is the simple and direct method by which magnetic field concepts are handled. First d-c theory is considered, with d-c circuit analyses by the mesh and model methods. This is followed by electric field theory, magnetic field theory, inductance, capacitance, and nonlinear circuit elements.

COMPONENTS HANDBOOK. (Massachusetts Institute of Technology, Radiation Laboratory Series. Volume 17). Edited by J. F. Blackburn. McGraw-Hill Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 626 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $8. This book codifies available information on the properties and characteristics of electronic components. Fixed components—wires, cables, resistors, and so on—are treated in the first part which also includes material on various types of contact rectifiers. The second part deals with electromechanical devices, while the third part is devoted to vacuum tubes and includes a brief summary of the properties of cathode-ray tubes. The results of original measurements made at the Radiation Laboratory on manufactured components are included.

COSMIC RAY PHYSICS. By D. J. X. Montgomery. Princeton University Press, Princeton, N. J., 1949. 370 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5. Emphasizing the experimental aspect, this book presents a survey of the entire field of cosmic-ray studies. It is intended for those with intermediate or advanced training in branches of physics other than cosmic rays. It is not a laboratory handbook nor does it give a definitive historical treatment, but discusses and explains various experimental techniques. Principles underlying the operation of some cosmic-ray apparatus are given, and the various components of cosmic radiation are discussed.

ECONOMICS OF INDUSTRIAL MANAGEMENT. By W. Rautenstrauch and R. Villers. Funk and Wagnalls Company, New York, N. Y., 1949. 451 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5. With a view to practical use in all situations, this book applies the science of industrial economics to industrial engineering and accounting. Outstanding features are a detailed description of the latest developments of the break-even chart process of analysis, a consideration of the fundamental principles involved in the study of industrial costs, and an analysis of the situation of business as part of the "national plant" as a whole.

ELECTROMECHANICAL TRANSDUCERS AND WAVE FILTERS. By W. P. Mason. Second edition. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; and London, England, 1948. 419 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Presents the fundamental analogies and interconnections between electrical and mechanical theory. The present edition incorporates a number of new topics, some of them growing out of work on transducers and filters during the war. The subjects selected have been those which round out and apply the methods already described in the book which cover electric network theory, acoustic equations, vibration of membranes and plates, and various electromechanical systems.

STEAMBOILER YEARBOOK AND MANUAL (IV). Edited by S. D. Scorer. Paul Elek Publishers, Ltd. London, E.C.1, England, 1948. 589 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$inches, cloth, 30s. Contains an accumulation of useful data on the steam generating field. Part I presents illustrated description of almost every kind of steam boiler and associated plant and is a guide to modern British steam boiler practice. Part II deals mainly with operating problems and incorporates material on modern boiler practice and development taken from English and foreign sources.

TELEPHONY, A DETAILED EXPOSITION OF THE TELEPHONE EXCHANGE SYSTEMS OF THE BRITISH POST OFFICE. Volume I. General Principles and Manual Exchange Systems. By J. Atkinson. Sir Isaac Pitman and Sons, Ltd., London, W.C.2, England, 1948. 513 pages, illustrations, diagrams, charts, tables, 10 by 7 inches, cloth, 35s. Intended for those engaged in the installation and maintenance of telephone exchange equipment, this comprehensive work is primarily concerned with signalling and switching aspects of telephony. Volume I is devoted to general principles and manual exchange systems. Volume II, now in preparation, will deal with automatic exchange systems. A knowledge of elementary d-c and a-c theory is assumed.

THEORY AND APPLICATION OF $\int_0^z e^{-x^2}dx$ AND $\int_0^z e^{-p^2y^2}dy \int_0^y e^{-x^2}dx$. By J. B. Rosser; reproduced by arrangement with the Office of Technical Services, Department of Commerce, by Mapleton House, Publishers, 5415 17th Avenue, Brooklyn 4, N. Y., 1948. 192 pages, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $8. In this book the known methods for evaluating the single integral are collected and extended to more general values of z. Suitable means for estimating the accuracy of computations are provided. Additional methods for computing the single integral and methods for the double integral are presented for the first time. Applications of these integrals are in the theory of probability and statistics, the theory of optics, the theory of heat transfer, and the theory of electrochemical diffusion.

VECTORIAL MECHANICS. By E. A. Milne. Interscience Publishers, 215 Fourth Avenue, New York, N. Y., 1948. 382 pages, diagrams, $9^3/_4$ by 6 inches, cloth, $7.50. Demonstrates the use of vectorial methods in the establishment of general theorems and in the solution of problems in the field of mechanics. It begins with a discussion of vector algebra containing all the results needed for reading the whole volume. This is followed by a systematic account of line vectors. Part 3 deals with dynamics and contains a section on kinematics. Rigid dynamics and impulsive motion are also considered.

WAVE FORMS. Edited by B. Chance, V. Hughes, E. F. MacNichol, D. Sayre, and F. C. Williams. (Massachusetts Institute of Technology Radiation Laboratory Series, volume 19). McGraw-Hill Book Company, New York, N.Y.; Toronto, Ontario, Canada; London, England, 1949. 785 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $10. Describes the generation and use of precisely controlled voltages and currents having various time dependence and duration. Introductory chapters present new methods of wave shaping by linear circuit elements and negative feedback amplifiers. The properties of vacuum tubes as nonlinear circuit elements and their applications to waveform manipulations are presented in detail. The operation of various types of multivibrators, blocking oscillators, and other basic circuits is discussed. Wave forms of precisely adjustable duration are emphasized.

FRACTIONAL-HORSEPOWER ELECTRIC MOTORS: A GUIDE TO TYPES AND APPLICATIONS. By E. K. Bottle. Charles Griffin and Company, Limited, London, England, 1948. 209 pages, diagrams, charts, tables, 15s. Addressed to the inventor and designer of motor-driven appliances, this book considers fractional-horsepower motors from the viewpoint of selection of the best type to suit given requirements. Motors for special duties are discussed, including light weight, high-speed machines for aircraft work, and telemotors. There is also a review of the various types of equipment by which small motors can be controlled.

GRUNDZÜGE DER TENSORRECHNUNG IN ANALYTISCHER DARSTELLUNG. (TEIL I, TENSORALGEBRA.) By A. Duschek and A. Hochrainer. Second edition. Springer-Verlag, Vienna, Austria, 1948. 129 pages, diagrams, tables, $8^1/_4$ by $5^1/_2$ inches, paper, $2.70. The first part of a book on tensor analysis presents the basic principles and fundamentals of tensor algebra. It is of interest not only to mathematicians and physicists, but to technicians in industrial research and computation departments as well. A knowledge of college mathematics is assumed.

HOW TO KEEP INVENTION RECORDS. By H. A. Toulmin, Jr. Research Press, Dayton, Ohio, 1948. 78 pages, tables, 8 by $5^1/_4$ inches, cloth, $2.50. Dealing with the measures necessary to protect patentable material, the first part discusses the general nature of industrial property and monopolies granted to protect it. In the second part, a practical method of insuring the recording of dates is presented in a series of a dozen forms. A final chapter deals with the methods of patent investigation.

INDUSTRIAL ELECTRICITY. Volume 2, Alternating-Current Practice. By W. H. Timbie and the late F. G. Willson. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1949. 781 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $5.96. Provides the reader with a thorough knowledge of the fundamentals of alternating current in practice and in theory. Following the application of a particular principle, the principle itself is explained. After theory come examples which take up other applications, followed by problems to be worked out. A knowledge of simple algebra, arithmetic, and d-c principles is assumed.

METALLURGY AND MAGNETISM. By J. K. Stanley. American Society for Metals, Cleveland, Ohio, 1949. 156 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4. Based on lectures given at the Thirtieth National Metal Congress, this book points out the relation existing between the fields of metallurgy and magnetism. It considers magnetic theory, a classification of magnetic materials, factors affecting magnetic properties, and magnetic analysis as a metallurgical tool. Numerous references are given so that the interested reader can pursue the subject further.

PRINCIPLES OF MECHANICS. By J. L. Synge and B. A. Griffith. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England, 1949. 530 pages, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $5. This volume is a text for intermediate courses in mathematics, physics, and engineering mechanics departments. The principal revision of this second edition occurs in the rewriting of the account of the motion of a charged particle in an electromagnetic field. Other changes include an amplification of the treatment of principal axes of inertia, and revisions in the material on Foucault's pendulum, the spinning projectile, and the gyrocompass.

PROPERTIES OF SOFT SOLDERS AND SOLDERED JOINTS. (Research Monograph Number 5). By J. McKeown, with a foreword by H. Moore. British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1, England, 1948. 118 pages, illustrations, diagrams, charts, tables, 10 by 6 inches, cloth, 17s. 6d.; $4. This monograph describes the work carried out and the results obtained in a wartime research on solders of varying composition. The section on soldering power tests includes bit-soldering, area of spread, and capillary penetration tests. The section of mechanical properties covers bulk solders, hot tearing, and creep and fatigue tests on soldered joints.

RADIO AMATEUR'S HANDBOOK. 26th Edition, 1949. American Radio Relay League, West Hartford, Conn., 736 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_2$ inches, paper, $2. This standard manual of amateur radio communication is revised and restyled in the light of current needs as a radio construction manual, reference work, and training text. A large assortment of new equipment has been added to the receiver and transmitter chapters, material on single-sideband telephony included, and a new section on practical filter design added. A comprehensive treatment is given of keying methods and techniques, antennas and transmission lines, and radiotelephony.

STATISTICAL YEAR-BOOK OF THE WORLD POWER CONFERENCE Number 4, Data on Resources and Annual Statistics for 1936–1946. Edited by F. Brown. World Power Conference, 201–2 Grand Buildings, Trafalgar Square, London, W.C.2, England, 1948. 212 pages, tables, 11 by $8^1/_2$ inches, cloth, £2:5s. This compilation contains statistics of the resources, production, stocks, imports, exports, and consumption of power and power sources in all the countries of the world for which it was possible to obtain information. The power sources included are coals, brown coal and lignite, peat, coke, manufactured fuel, wood, petroleum, benzoles, alcohols, natural gas, manufactured gas, water power, and electricity. Most of the statistics were supplied by government organizations in the countries concerned, and conform to standard definitions which are reproduced in the text.

TABLES OF SCATTERING FUNCTIONS FOR SPHERICAL PARTICLES. (Applied Mathematics Series 4). United States Bureau of Standards, for sale by Superintendent of Documents, Government Printing Office, Washington, D. C. 1948, 119 pages, tables, $10^1/_4$ by 8 inches, paper, 45 cents. These tables of intensities, prepared by the Computation Laboratory of the National Applied Mathematics Laboratories, are based on the theory set forth by Gustav Mie. Intensity functions give the angular distribution of intensity and the total light scattered by a small spherical particle as a function of a certain parameter. These factors can be used to determine particle size and concentration as explained in the introduction and by the use of the tables. An extension of the tables provides values for a problem in the application of microwave radar.

TEXTBOOK OF RADAR, a Collective Work by the Staff of the Radiophysics Laboratory, Council for Scientific and Industrial Research, Australia. Published by Angus and Robertson, Sydney, Australia and London, England; distributed by P.D. and Ione Perkins, South Pasadena, Calif., 1947. 579 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $13. Covering the field of radar techniques this book is of interest to physicists and engineers who wish to keep abreast of the developments in the microwave region. It is also suitable as a text for graduate and research students and for engineers engaged in research and development in industry. The different components of radar equipment are considered in detail, and the applications of radar in the air, on the ground, and on the sea are discussed.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

The Effects of Higher Income Taxes on Electric Utility Enterprises, by H. B. Dorau and J. R. Foster. Presents the case against imposing additional taxes on electrical utilities. 104 pages. Available at $2.50 from EcoStat Research, Inc., 88 Chestnut Street, Ridgewood, N. J.

Electric Power Engineering in Germany During the Period, 1939–1945. B. I. O. S. Report Number 11. Discusses German developments in generating and transmission equipment, power cables, mercury-arc rectifiers, and batteries. 56 pages. Available at 45 cents from the British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

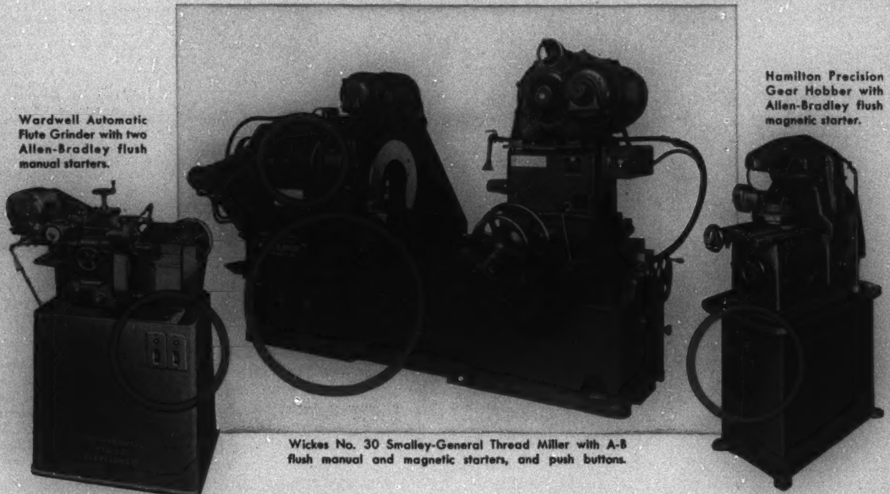
Phase-Sensitive Indicating Devices, by H. C. Roberts. University of Illinois Bulletin, Engineering Experiment Station Reprint Series Number 41. Discusses direction-sensitive, phase-selective, and phase-discriminating devices, and deals with dynamometers, vibration galvanometers, mechanical rectifiers, and electronic wattmeters. 18 pages. Priced at 15 cents. Remit orders to The Engineering Experiment Station, University of Illinois, Urbana, Ill.

1949 Transit Fact Book. Gives data on local transit industry of the United States, including final figures on operations during calendar year 1948. 16 pages. Available from the American Transit Association, 292 Madison Avenue, New York 17, N. Y.

Bibliography of Electro-organic Chemistry, Part I, by S. Swann, Jr., University of Illinois Bulletin, Engineering Experiment Station Circular Series Number 50. Contains author index of reports, books, articles, and unpublished dissertations. 114 pages. Sells for $1. Available from The Engineering Experiment Station, University of Illinois, Urbana, Ill.

Build In Your Motor Controls

and improve the appearance of your machines



Wardwell Automatic Flute Grinder with two Allen-Bradley flush manual starters.

Hamilton Precision Gear Hobber with Allen-Bradley flush magnetic starter.

Wickes No. 30 Smalley-General Thread Miller with A-B flush manual and magnetic starters, and push buttons.

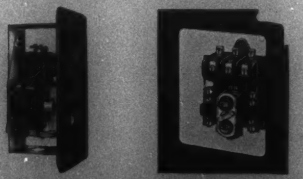
Modern styling calls for flush mounted starters that fit into machine bases. Above are a few examples of machine tools designed for "built-in" controls with flush covers.

Notice the smooth appearance of the machine bases. There are no control boxes to break the streamlined design . . . no exposed conduits to clutter the installation.

Allen-Bradley flush mounted starters are available for manual or automatic operation in various standard ratings and constructions. We shall be glad to send descriptive bulletins.

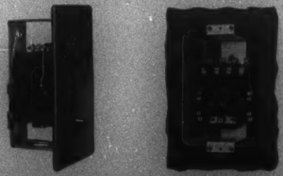
Allen-Bradley Company, 1316 S. Second St., Milwaukee 4, Wis.

BULLETIN 609 MANUAL STARTER



At left—A-B flush mounted manual starter in open type construction for enclosed recesses. At right—A-B manual starter in flush mounted cabinet for installation in open recesses.

BULLETIN 709 MAGNETIC STARTER



At left—A-B flush mounted automatic starter in open type construction for enclosed recesses. At right—Form 1 A-B unit installed in enclosed machine recess, with cover off.

A-B

Quality

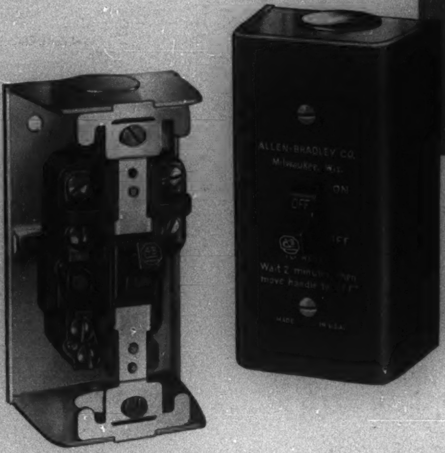
ALLEN-BRADLEY

[illegible]

QUALITY

TROUBLE FREE MOTOR STARTERS

with RELIABLE OVERLOAD PROTECTION



For Fractional Horsepower Motors

The National Electrical Code requires overload protection for all fractional horsepower motors started automatically or by remote control. The Bulletin 600 switch satisfies this need. Its dependable, accurate, thermal breaker trips the switch under a sustained overload, and protects the motor against burnout.

QUICK MAKE AND BREAK CONTACTS—The simple, rugged, over center mechanism provides quick make and quick break contact action . . . therefore, long contact life.

GENEROUS WIRING SPACE—Though compact, this small switch provides plenty of wiring space. Its metal cover slips off, exposing front and two sides.

EASY TO INSTALL—No need to remove the starter from the enclosure during installation—saves at least 10 minutes of installation time.

ATTRACTIVE APPEARANCE—This starting switch, with its clean, modern lines, is a sales asset to any motorized machine.

Allen-Bradley Company
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES FOR SMALL MOTORS

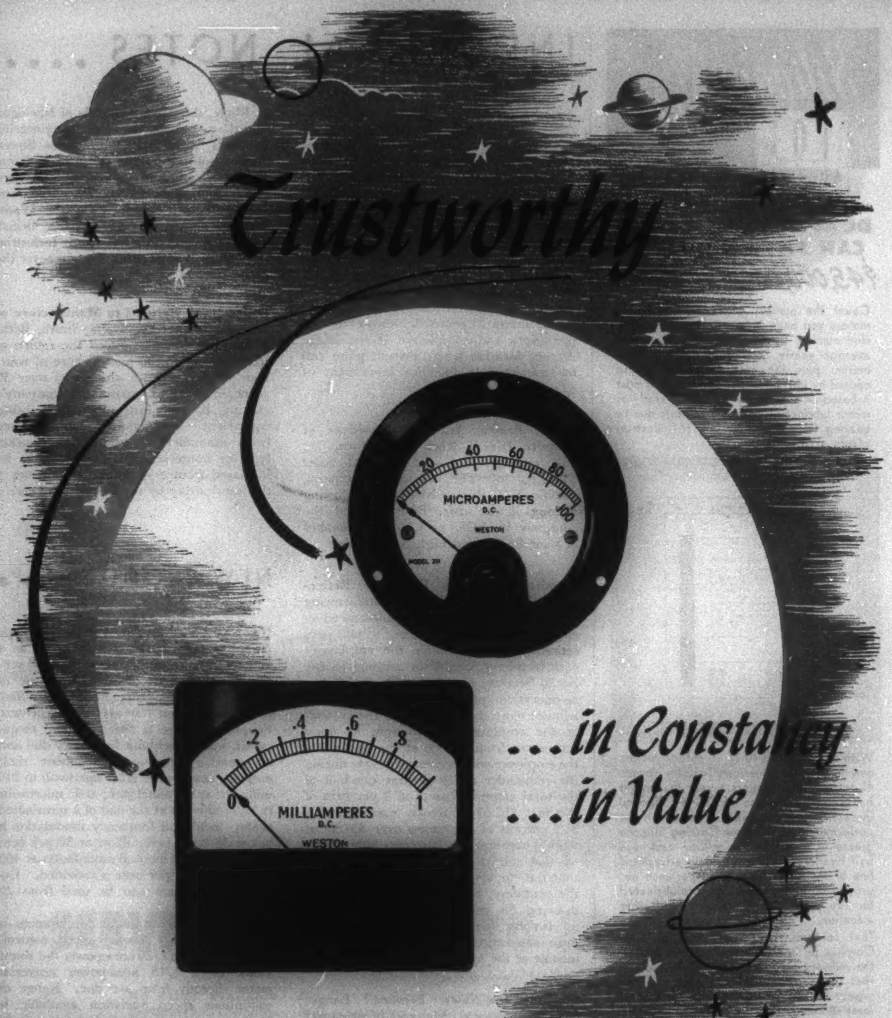
For watertight or weatherproof jobs—with pilot light.

Cast iron, sealed for hazardous gas.

Three way "Hand-Off-Automatic." Selector switch is on left side.

Bulletin 600 starting switch fits any standard conduit switch box.

Available in many enclosures with or without pilot light indication.



Wherever an electrical measurement provides essential information . . . whether in the manufacture of electrical components, the inspection of purchased parts or finished products, or in the operation of some electrical machine . . . far-sighted buyers specify "meters by WESTON". Experienced buyers know that in value, and in performance, there is no substitute for WESTON instruments. Ask your nearest WESTON representative for all the facts, or write for bulletin A-7-B. WESTON Electrical Instrument Corporation, 664 Frelinghuysen Avenue, Newark 5, New Jersey.

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Rochester • San Francisco • Seattle • St. Louis • Syracuse • Tulsa • In Canada, Northern Electric Company, Ltd., Powerlite Devices, Ltd.

Silicone News

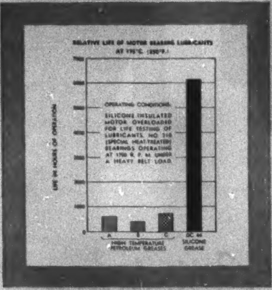
DC SILICONES

IN THE BEARINGS OF ELECTRIC MOTORS

DC 44 SILICONE GREASE CAN SAVE INDUSTRY

$45,000,000.00 A YEAR!

Count the number of conventional-type motors you have in your plant. Multiply that number by $4.52 and you have the average yearly cost of lubricating these motors plus the cost of motor failure caused by improper lubrication. That cost is based on a carefully conducted study of motor lubrication and outage costs due to bearing failure in a variety of industrial plants across the country.



With an estimated 10 to 15 million motors now in service, American industry spends 45 to 67 million dollars a year that might be saved by the use of DC 44 Silicone Grease. That possibility is based on the performance of this Dow Corning Silicone grease in about half a million cartridge ball bearings used in a widely advertised line of industrial motors. Experience has proved that these bearings, prelubricated for life with DC 44, require no further attention.

That confirms the testing done by Dow Corning, by bearing manufacturers and by the military establishment. Data such as that shown above indicate that you can expect DC 44 Silicone Grease to last at least 10 times longer than high temperature petroleum greases.

For more information about Dow Corning Silicone Greases, phone our nearest branch office or write for data sheet M-13

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INDUSTRIAL NOTES ....

New S and C Plant. The S and C Electric Company has announced the start of construction of a new manufacturing plant at 6600 Ridge Avenue, Chicago, Ill. The first building will total 51,000 square feet, and is scheduled for occupancy by March, 1950, at an estimated cost of $600,000. It will be used solely for the final assembly of the company's high voltage protective and interrupting equipment. Fabrication operations, engineering, sales and administrative functions will continue at the present 4435 Ravenswood Avenue address in Chicago. Eventually, however, all operations will consolidate at the Ridge Avenue location where present plans call for an ultimate facilities investment of $2,000,000.

C. E. Brown, Jr., Vice-President of Okonite Dies. Charles E. Brown, Jr., 55, Vice-President and General Sales Manager of The Okonite Company, Passaic, N. J., died in November, following a long illness. Mr. Brown joined the company in 1925, as Chicago Manager of their Power and Light Department.

Ohmite Announces Employee Retirement Plan. The Ohmite Manufacturing Company, Chicago, Ill., has announced an employees' retirement plan, which pays retirement benefits after the employee's 65th birthday, payable in addition to any Social Security benefits. Although it is a co-operative plan, the company contributes more than three times the amount of the employee contribution, as upon retirement from service at the age of 65, the employee will receive every year during the remainder of his lifetime one-half of the total amount (based on 2 per cent of the first $57.69 of weekly earnings, plus 3$^1/_2$ percent of the excess over $57.69 of weekly earnings) he has contributed since he first joined the plan. In the event that the employee terminates service with the company, he has the option of withdrawing his contributions, plus interest, or leaving his contributions with the insurance company to provide a retirement income at the age of 65.

Westinghouse News. Bernard F. Langer has been appointed Manager of structural and heat engineering of the Westinghouse Electric Corporation's Atomic Power Division. Also, the Westinghouse Electric International Company has announced the retirement of Ernest P. Schroeder, who has been the International Company's Resident Representative at the Westinghouse East Pittsburgh Works since 1936. Angus G. Scott, formerly Assistant Resident Representative at East Pittsburgh, will succeed Mr. Schroeder.

Pyramid Instrument Expands Sales Program. The Pyramid Instrument Company, New York, N. Y., has appointed four new sales representatives, to cover the following territories: Koehler-Pasmore Company, 11833 Hamilton Street, Detroit 3, Mich., the lower peninsula of Michigan and the city of Toledo, Ohio; Engineering Products, 2208 East Washington Street, Indianapolis, Ind., the states of Indiana, Kentucky, southern Illinois, and southern Ohio; Northwestern Agencies, 4130 First Avenue South, Seattle 4, Wash., Washington, Oregon, Idaho, Montana, British Columbia, and Alaska; and Industrial Specialties Sales, Tampa, Fla., to cover the entire state of Florida.

Roller-Smith Returns to Manufacture of Watt-Hour Meters. Roller-Smith, Bethlehem, Pa., has announced the return of the company to the manufacture of watt-hour meters after an absence of over 30 years, in order to expand the company's existing line of instruments and other equipment. Production of meters now being manufactured (single phase socket type for house service) is expected to be increased from a few hundred to over a thousand a day by the first of the year.

NEW PRODUCTS ••

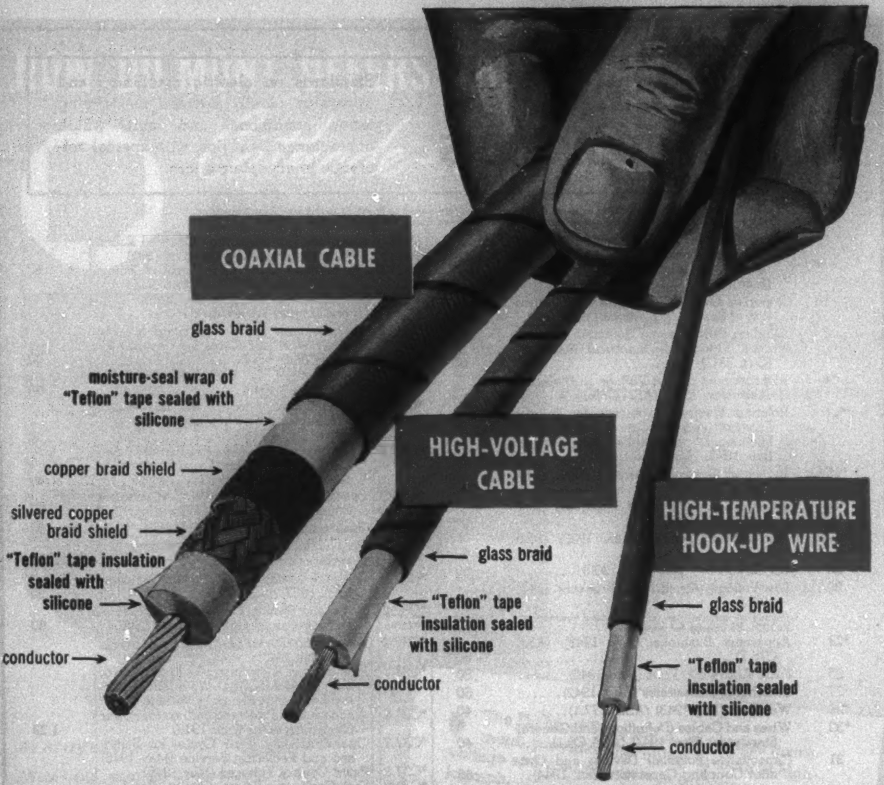
New General Radio Products. Type *1001-A* standard signal generator is a general purpose, amplitude-modulated generator suitable for standard Institute of Radio Engineers and Radio Manufacturers Association tests on radio receivers. Frequency range is five kc to 50 megacycles, with logarithmic frequency dial and an auxiliary frequency-increment dial; output voltage range is 0.1 microvolt to 200 millivolts at the panel jack; 0.05 microvolts to 100 millivolts at the end of a terminated cable; incidental frequency modulation is below 38 parts per million at 30 per cent modulation and internal modulation at 400 cycles up to 80 per cent is provided. External modulation can be used from 20 cycles to 15 kc.

Another General Radio development is the Type *1701-A* Variac speed control, which controls a 1/20 horsepower d-c shunt motor or a 1/15 horsepower universal motor directly from a-c line. Range of continuous speed variation available is from motor rated speed down to nearly zero at constant torque. The motor can be reversed almost instantly by flipping the forward-reverse switch.

For additional information on the products described above, write to the General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass.

Electrical Insulation. Quinorgo number *4000* electrical insulation is a new addition to the line of Johns-Manville products, developed specifically for use as a class *B* (hot spot temperatures to 130 degrees Centigrade) electrical insulating carrier sheet to be combined with other electrical insulating sheets or films. Quinorgo *4000* con-

(*Continued on page 22A*)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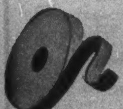
glass braid
"Teflon" tape insulation sealed with silicone
conductor
HIGH-TEMPERATURE HOOK-UP WIRE
glass braid
"Teflon" tape insulation sealed with silicone
conductor

"TEFLON"* TAPE INSULATION SERVES FROM –80° TO 500°F.



No other available material has the combination of low electrical losses and heat-resistance of Du Pont "Teflon" tetrafluroethylene resin.

"Teflon" tape is seeing wider and wider use in such applications as insulation for wire and cable, ground insulation for motors and generators, conductor and layer insulation in transformers and coils. Its power factor is less than 0.0005 and its dielectric constant only 2.0 over the entire spectrum measured to date, 60 cycles to 30,000 megacycles. Its dielectric strength is excellent and is unaffected by temperature changes up to at least 400°F. The tape gives service up to 500°F. "Teflon" tape has excellent mechanical strength and pliability . . . at temperatures as low as –80°F. In wrapped construction it fits even more tightly as the temperature is raised. It has zero water-absorption, and is unaffected by outdoor weathering.

"Teflon" is supplied by Du Pont in the standard shapes of rods, tubes, sheets, beading, and tape, and in molding powder, both shredded and granular. WRITE NOW for more data on the properties and electrical uses of "Teflon"!

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BETTER THINGS FOR BETTER LIVING
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Standards on electric machinery and apparatus chiefly devoted to defining terms, conditions, and limits which characterize behavior, with special reference to acceptance tests.

A discount of 50 per cent, on single copies is allowed to Institute members except as noted. Such discount is not applicable on extra copies unless ordered for other members.

1	General Principles Upon Which Temperature Limits are Based in the Rating of Electric Machines and Apparatus (June 1947)	$ 0.80
1B	Report on Guiding Principles for Specification of Service Conditions (May 1944)	.40
3	Guiding Principles for Selection of Reference Values for Electrical Standards (Oct. 1943)	60
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600	Recommended Specification for Speed Governing of Prime Movers Intended to Drive Electric Generators (May 1949)	.60
601 602	Preferred Standards and Standard Specification Data for Large 3600-rpm, 3-Phase, 60-Cycle Condensing Steam Turbine Generators (May 1949)	.60
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*C8.5 *C8.6 *C8.7	Specifications for Cotton Covered Round Copper Magnet Wire (April 1936) Specifications for Silk Covered Round Copper Magnet Wire (April 1936) Specifications for Enameled Round Copper Magnet Wire (April 1936)	.60
*C8.12	Specifications for Cotton Braid for Insulated Wire and Cable for General Purposes (Feb. 1942)	.60
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*C8.20	Specifications for Heavy-Walled Enameled Round Copper Magnet Wire (Nov. 1939)	.40
*C29.1	Insulator Tests (Sept. 1944) (AIEE 41)	.80
*C34.1	Pool Cathode Mercury-Arc Power Converters (Jan. 1949)	1.20
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*C42	Definitions of Electrical Terms (Aug. 1941) (No discounts apply on price of this publication) ($1.25 outside postal USA)	1.00
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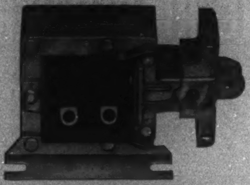

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Elements of Nucleonics for Engineers

This publication contains a series of articles on nucleonics published in ELECTRICAL ENGINEERING and sponsored by the AIEE committee on nucleonics which was formed in 1946 in recognition of the very direct interest of the electrical engineer in the field of nuclear physics. Now combined in a single volume, the articles provide a convenient primer of nuclear theory.

CONTENTS

The Atom and Its Nucleus
by J. J. Smith

The Relation Between Energy and Mass
by Frederick Seitz, Jr.

The Nucleus—Its Structure and Reactions
by W. E. Shoupp and Hugh Odishaw

Nuclear Engineering
by E. U. Condon

Detection and Measurement of Nuclear Radiation
by G. Wesley Dunlap

The Separation of Isotopes
by G. Wesley Dunlap and R. M. Lichtenstein

Cascades Used in Isotope Separation
by Harold C. Urey

Nuclear Reactors—Some Basic Considerations
by F. L. Friedman

High-Energy Particle Accelerators
by J. R. Woodyard

Physical and Medical Aspects of Radiation
by L. L. German and H. M. Rozendaal

Nuclear Reactors for Power Generation
by Ward F. Davidson

Suggested Bibliography
Sources of further information

Copies of "Elements of Nucleonics for Engineers" are available at 80 cents each (40 cents to AIEE members) and may be obtained from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

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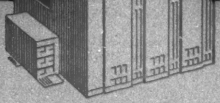


Instruments "Check-Rein" 240,000 Horsepower!

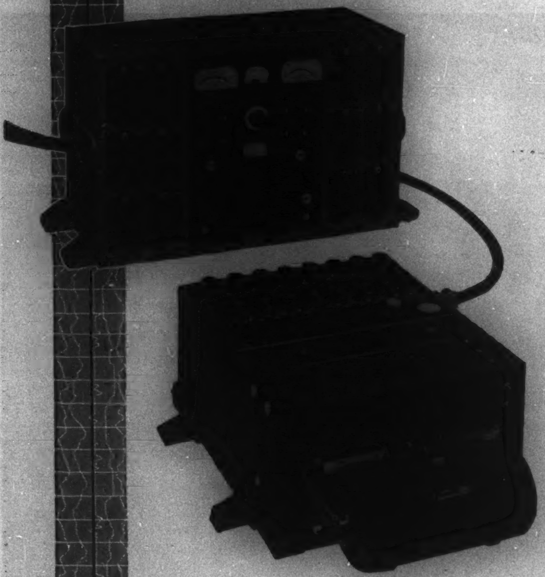
When the power load builds up and up, it's Westinghouse Instruments that give the tip-off! Another generator is called into action—steady voltage flows over the network...

This is a familiar routine at the new B. C. Cobb Station, owned by Consumers Power Company. This modern steam electric generating plant, located on the shores of Lake Muskegon, Michigan, has a rated capacity of 180,000 kw, or 240,000 horsepower. Westinghouse Instruments have been standardized on here—keep a vigilant watch over power that is generated at 14,400 volts, then transformed to 22,000, 44,000 and 140,000 volts.

Serving as the "eyes" for this massive power system calls for instrument reliability to the nth degree. We believe Westinghouse Instruments meet this challenge. *You can be sure* of the complete line of Westinghouse Instruments—from calling the turn on a microamp. to keeping a "check-rein" on all the concentrated horsepower America's genius can devise.

Westinghouse Instrument Specialists are available in the field for consultation. Call your nearest Westinghouse office, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40379

Westinghouse
INSTRUMENTS



Equipment for Strain Recording

Illustrated is a complete 12-channel portable laboratory for precision strain determination from static strain to a frequency of 5000 cycles per second, using resistance gages that are attached by cement to the points of strain.

In the field or in the laboratory...on a high-speed locomotive or in the air... HATHAWAY strain recording equipment is ideal for the recording of STATIC AND DYNAMIC STRAIN in structural members and machines in operation.

Complete with all necessary balancing controls and monitoring instruments, precision calibrating device, power supply equipment and oscillator, and type S8-B Oscillograph.

TYPE MRC-15 12-element Strain Gage Control Unit. Fully described in Technical Bulletin SP 195 J

Type S8-B 12- to 48-element Oscillograph Fully described in Technical Bulletin SP 165 J

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO

(*Continued from page 16A*)

tains a small amount of resin (three per cent or less) which reduces absorption and penetration. Because of this factor, shellacs or other adhesive mixtures can be spread on one side of the sheets without striking through to the reverse side. At the same time the opposite surface remains ready for absorption of treating varnishes used in the further processing of equipment. Thus Quinorgo *4000* may be rapidly assembled with organic or inorganic electrical insulating sheets or films such as mica, glass cloth, plain or varnished cambric, cellophane, kodapak, rag and kraft papers. Further information on the new insulation is available from Johns-Manville, 22 East 40th Street, New York 16, N. Y.

Manual Autotransformer-Type Starter. A new manual autotransformer-type starter for squirrel-cage motors is offered by the Allen-Bradley Company, Milwaukee, Wis. It is available in four sizes from 5 horsepower, 220-440-550 volts, to 250 horsepower, 440-550 volts; or 25, 50, and 60 cycles. Two automatic reset overload relays are standard equipment in all starters, and all starters have an adjustable time-delay mechanism for controlling the length of the accelerating period before switching the motor from starting to running taps. The new line comes with air-break contacts and with oil-immersed contacts. Additional data on autotransformer-type starters may be obtained in Bulletin *646* from the company.

General Electric Developments. The General Electric Company has announced the following recent developments:

1. A new plate-type rheostat furnished in three forms: the 6-inch form (27 resistance divisions), the 9-inch form (52 resistance divisions), and the 12-inch form (70 resistance divisions). The rheostat has been designed for field control of d-c shunt- or compound-wound motors, self-excited generators, exciters, separately-excited generators, and synchronous motors.
2. A new line of braidless disconnecting switches for 7.5 to 69 kv outdoor service, with a rating extension of the high-voltage (115, 161, and 230 kv) units previously available. Designated Type *RF*, the new switch features silver-to-silver line pressure contacts, a simplified operating mechanism, and complete elimination of current-carrying braids. On the hinge end of the switch, the silver surface of the movable blade engages the silver surface of a U-shaped clip, which is backed by adjustable stainless steel compression springs. This assures a positive contact at all times during opening and closing operations, and prevents burning of the switch. Additional information is given in Bulletin *GEA-4980*.
3. Tri-Clad single-phase integral-horsepower capacitor motor, weighing 15 to 20 per cent less than the old model. It has a totally enclosed built-in starting switch to keep foreign matter from the contacts, and a

(*Continued on page 26A*)

You get Double* Protection

with RoMarine - RoPrene

*RoMarine . . . superaging, heat and moisture-resistant insulation

plus

*RoPrene . . . all-resistant Neoprene sheath

Underwriters' Approved as Type USE—Style RR
First to be approved by Civil Aeronautics Administration for airport wiring under Specification L-824

RoMarine-RoPrene enjoys its high popularity as a dependable power cable with good reason. It offers *double protection* against circuit failures. First, its RoMarine insulation is both heat and moisture resistant. Second, its RoPrene sheath is highly resistant to oils, acids, corrosive fumes and flame. It is unaffected by electrolysis, weather hazards or extreme temperature change.

Add to this, versatility of application and you can understand why more and more utilities and industrials are swinging to RoMarine-RoPrene, the all-purpose cable. Installed direct in earth, in conduit, in air, or in runs combining all three, RoMarine-RoPrene is ideal for secondary networks, underground entrances, street lighting, station control circuits, or general purpose wiring. It is cheaper than lead sheathed cable. It is lighter . . . easier to handle and splice . . . Write for Specification RR-1 for test data and construction details.

It Costs Less to Buy the Best . . . Buy Rome Cable

ROME CABLE CORP., Dept. EE-1, Rome, N. Y.
Please send me Specification RR-1 (Test Data).

Name ....
Company ....
Address ....
City .... *State* ....

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From Bar to Finished Wire
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HERE IS A LOW-COST PHENOLIC TUBE MATERIAL OF GREAT STRENGTH AND GOOD INSULATING PROPERTIES!

Its additional advantages of high dielectric strength, low moisture absorption and good machining properties combine to make CLEVELAND COSMALITE* the FIRST CHOICE of the radio and television industries for coil form and similar assemblies. Its dominant position in these industries is now meeting with rapid recognition and use in many kindred electrical applications.

★ ★ ★

TELL US YOUR NEEDS. You, too, may find this product especially advantageous for some special use where quality and low-cost factors are essential.

CLEVELAND COSMALITE is available in various types, diameters, thicknesses and lengths up to 8½ feet. It may be punched, notched, threaded and grooved to meet individual requirements.

YOUR INQUIRIES addressed to our Engineering Dept. will receive intelligent attention.

*Reg. U.S. Pat. Off.

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PLANTS AND SALES OFFICES at Plymouth, Wisc., Chicago, Detroit, Ogdensburg, N.Y., Jamesburg, N.J.
ABRASIVE DIVISION at Cleveland, Ohio
CANADIAN PLANT: The Cleveland Container, Canada, Ltd., Prescott, Ontario

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CLEVELAND CONTAINER PRODUCTS to meet your other requirements include PACKAGING . . . TUBES . . . ABRASIVES, ETC., ETC.

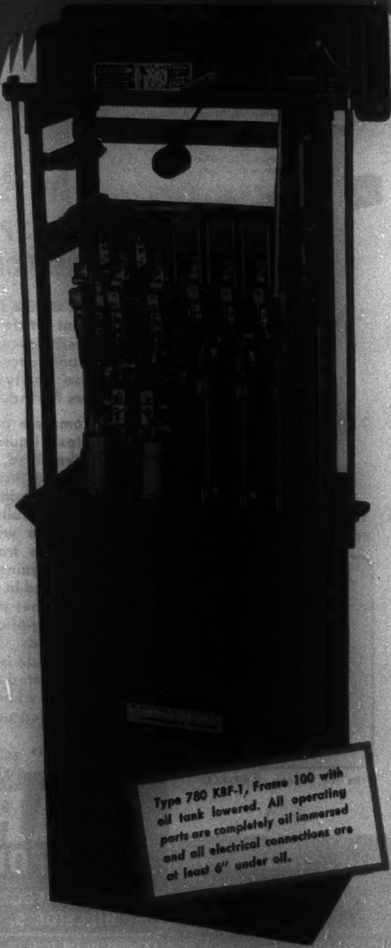
For dependability, use OIL-IMMERSED MOTOR CONTROL in corrosive and hazardous locations

Type 780 KBF-1, Frame 100, closed position. Note provision for straight-thru conduit connections.

FOR use in chemical plants, oil refineries, steel mills and cement plants—in locations where the atmosphere is charged with highly corrosive elements or explosive dust and gases—Rowan engineers designed the 780–1 series of oil immersed motor starters for Class I, Group D locations NEMA Type VIII enclosures.

Rowan type 780 KBF-1 Combination Starters, consist of heavy duty magnetic contactors of the clapper type, giving high speed closing and opening with positive roll and wipe action, magnetic overload relays with inverse time element by means of Rowan AIR SEAL dashpots, each relay is individually tested and calibrated. Safety disconnect switch is of the contactor type with quick make and break mechanism and equipped with Rowan time tested AIR SEAL fuses—top and tank are mechanically interlocked with safety disconnect handle for positive safety with provision for padlocking operating handle in the OFF position.

Complete information available in Bulletin form.



Type 780 KBF-1, Frame 100 with oil tank lowered. All operating parts are completely oil immersed and all electrical connections are at least 6" under oil.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD

NOW! the transformer of the future

FUTURE POSSIBILITIES

. . . It is to be expected that such activity (improvements) will continue in the future. Much of it can probably not be foreseen at this time. There are a few items, however, which might be mentioned as either distinct possibilities or highly desirable.

There is considerable promise of the production of a dry-type distribution transformer for pole top installation. The advantage will be less weight and lower maintenance. It seems possible that on such a transformer the case might be reduced to a minimum or perhaps be eliminated entirely.

Excerpt from "Distribution transformer" by Howard P. Seelye, Chief Electrical Engineer, The Detroit Edison Company in collaboration with other leading electrical engineers; ELECTRICAL WORLD, 75th Anniversary Issue, May 21, 1949.

MARCUS

DRY TYPE AIR COOLED DISTRIBUTION TRANSFORMERS

Months before the publication of this excellent article on distribution transformers, Marcus, a pioneer in the field, announced a new line of *all purpose* dry type distribution transformers for indoor or outdoor service.

The complete absence of hazardous oil or toxic liquid affords safety never before realized. Superior Class B and C heatproof insulation, such as fibreglass, mica, porcelain, new Johns-Manville Quinterra, etc., results in overload capacities unobtainable with Class A oil filled units. The entire transformer element is seal protected against oil, acids, moisture, etc., and is housed in a sturdy, scientifically ventilated, weather proof case which conforms with all applicable EEI-NEMA construction standards. This extremely versatile transformer can be used outdoors, pole or platform mounted or indoors at the load center, mounted wherever convenient with no expensive fireproof vault required.

Currently available in sizes to 100 KVA, voltages to 5000 V.

AIR-COOLED TRANSFORMERS EXCLUSIVELY
1 to 2,000 KVA up to 15,000 Volts to meet Individual Requirements
- DISTRIBUTION
- GENERAL PURPOSE
- UNIT SUBSTATION
- PHASE CHANGING
- ELECTRIC FURNACE
- RECTIFIER
- WELDING
- MOTOR STARTING

Write for Bulletin #49-ACO

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TRANSFORMER CO.
INC.
34 MONTGOMERY STREET
HILLSIDE 5, NEW JERSEY

PIONEERS IN THE FIELD OF AIR COOLED TRANSFORMERS

(*Continued from page 22A*)

centrifugal mechanism. In ratings from 1/2 to 5 horsepower, these high torque motors are available in two types: Type *KCS*, capacitor-start, designed for 115/230 volts, and Type *KCR* capacitor-run, a single voltage, 230-volt design. Any additional information on the new motors is contained in publication *GEA-5401*.

4. A new capacitor switch, designed to replace more expensive switching devices. Rated 15,000 volts, 100 amperes continuous, 3-phase, the switch will enable users to supply additional kilovars more economically by means of capacitors. The *B-1* capacitor switch is oil-immersed, electrically operated and constructed for outdoor use, and is intended to encourage capacitor installations on high voltage circuits. It is capable of switching its continuous current (100 amperes) at 15,000 volts.

Further information and any bulletins on the instruments mentioned above may be had by writing to the General Electric Company, Schenectady 5, N. Y.

Miniature Q Controls. The International Resistance Company, 401 North Broad Street, Philadelphia 8, Pa., has announced a new line of miniature controls, Type *PQ* with a 3-inch shaft, and Type *RQ* with a very short screw-driver slotted shaft. Both types have a power rating of 1/2-watt, 500 volts maximum. Salt spray materials protect metal parts from corrosion. Full details of these controls are available in Catalog Data Bulletin *DC-4*, from the company.

Load Tap Changer. The Moloney Electric Company has entered the tap-changing-underload field with a line of load tap changers and automatic control equipment which are arranged to provide a voltage regulation range of 20 per cent in 32 5/8 per cent steps. Features of the new load tap changer include a new principle of reactor switching, elimination of arcing duty from the tap selector switch, increased tap changer interrupting capacity, application of new contact and insulating materials, and combined spring accelerated and direct drive load switching. The load transfer and tap selector switches are actuated through two sets of intermittent gear drives, interlocked mechanically through spur gears to a common motor drive, producing definite relative timing of the two switches and of a reversing switch, and accurate placement of all current carrying parts. Additional details on the new line may be obtained from the Moloney Electric Company, St. Louis, Mo.

1200 Ampere Regulator By-Pass Switch. The James R. Kearney Corporation, 4236 Clayton Avenue, St. Louis 10, Mo., has introduced an automatic switching sequence for high-current capacity voltage regulators which is available in one unit—a 1,200-ampere Kearney regulator by-pass switch. The four steps required in removing regulators from the line are performed with one switch operation: regulator is by-passed, regulator leads are disconnected, and the exciting current is interrupted safely in an

(*Continued on page 32A*)

Average field service—
more than
a decade...

A 7,920 Kvar; 4,160 volt WYE, outdoor station-type C-D installation totalling 47,520 Kvar.

...and
still going
strong!

CORNELL-DUBILIER
CAPACITORS FOR POWER-FACTOR IMPROVEMENT

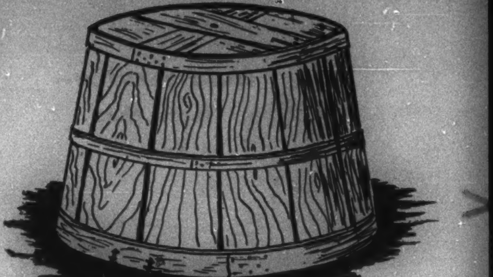
What goes into a C-D power-factor capacitor? The finest components and construction, of course . . . plus the "fourth dimensional" quality you can't see: the C-D "know-how" that comes from years of experience in building capacitors for power-factor improvement. That's why C-D installations remain in service for years—with little or no maintenance. And that's why leading utility engineers specify C-D. Consult your local C-D field engineer, or write for technical data to Cornell-Dubilier Electric Corporation, Dept.B10, South Plainfield, New Jersey. Other plants in New Bedford, Worcester, and Brookline, Mass.; Indianapolis, Ind.; Providence, R. I. and Cleveland, Ohio.

Follow the leaders
Demand dependable C-D Capacitors—built by capacitor specialists.

C-D Best by Field Test!

CORNELL-DUBILIER WORLD'S LARGEST MANUFACTURER OF CAPACITORS

Are you hiding your Professional Talents under the proverbial bushel basket?



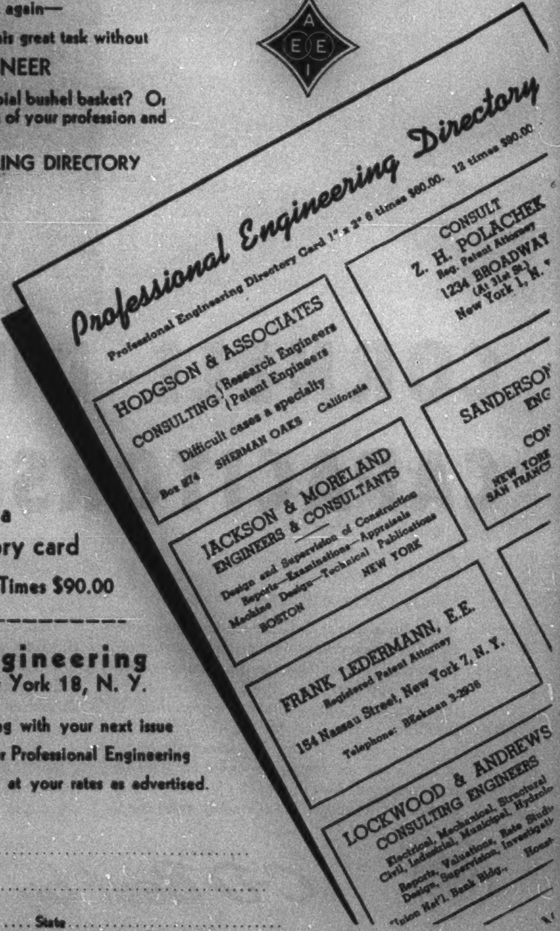
BILLIONS will be spent in the next few years to gear industry for the big job ahead of putting this World on its feet again—

It would be almost impossible to accomplish this great task without

THE ELECTRICAL ENGINEER

Are you hiding your talents under that proverbial bushel basket? Or are you ready to step out with the leading men of your profession and let the World know what you can do?

USE THE PROFESSIONAL ENGINEERING DIRECTORY



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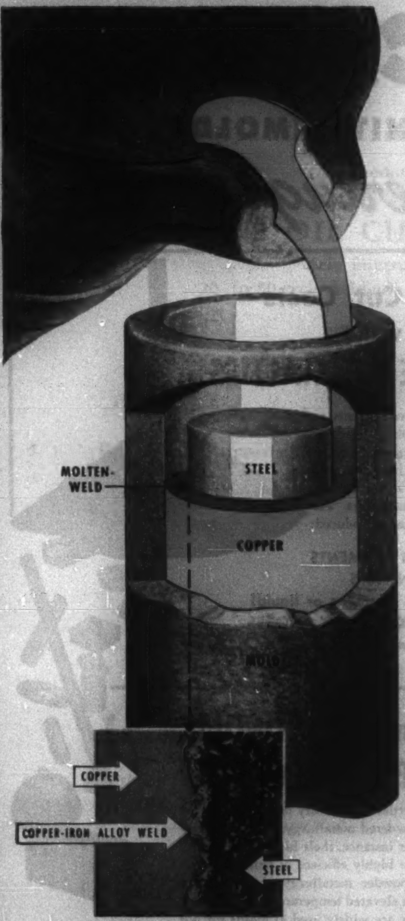
EVERY Copperweld GROUND ROD IS MOLTEN-WELDED —NOT COPPER-PLATED



This photomicrograph of the Molten-Weld shows how the grains of copper and steel interlock to form a permanent, continuous weld. No other process achieves this inseparable union.

WHAT'S THE ADVANTAGE?

By this unique Molten-Welding process—used only by Copperweld Steel Company—a uniformly thick sheath of pure copper is inseparably welded to an alloy steel core. Under carefully controlled conditions, the grains of both metals interlock to form a permanent, continuous weld. And from the moment of this union, Copperweld* performs as one metal. Hot rolling, cold drawing, pounding, or temperature changes cannot destroy the Molten-Weld in Copperweld Ground Rods.

WHAT DOES THE MOLTEN-WELD IN COPPERWELD MEAN TO YOU?

In service, this permanent Molten-Weld completely eliminates the possibility of harmful electro-galvanic action in the presence of moisture. There are no microscopic cracks, fissures, or pin holes in the thick copper exterior to admit moisture and give destructive rust a foothold.

So, for permanent grounding protection at lowest annual cost, insist upon Copperweld Ground Rods and get the rust resistance and conductance of copper plus the strength and easy-driving qualities of alloy steel. The time-tested dependability and economy of Copperweld products have been proved in service for 35 years.

**Trade Mark*

LOOK FOR THE NAME "COPPERWELD" -IT PROTECTS YOU!

Made By

COPPERWELD STEEL COMPANY, Glassport, Pa.

THEY'RE MOLTEN-WELDED Copperweld GROUND RODS -NOT COPPER-PLATED

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And All Their Distributors

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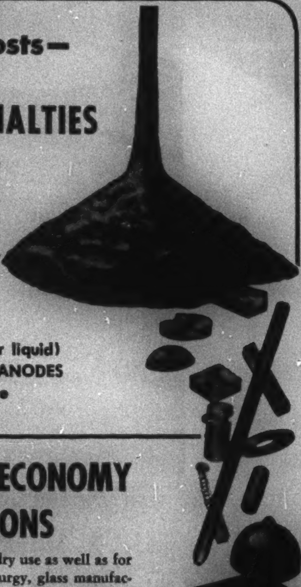
CARBON • GRAPHITE • MOLDED METAL

Engineering News

No. 6

Simplify design problems—Cut Costs—
Assure greater efficiency with
STACKPOLE CARBON-GRAPHITE SPECIALTIES



More and more throughout industry, the latest engineering developments are utilizing the oldest, most basic of all materials—carbon and graphite. Produced in many styles, shapes, sizes and mixes to match individual requirements, Stackpole carbon-graphite specialties offer practical, economical solutions to a wide range of mechanical, electrical and chemical problems involving such factors as friction, elevated temperatures, corrosion, arcing, shaft sealing and others. Following are but a few of the many standard and special items regularly produced:

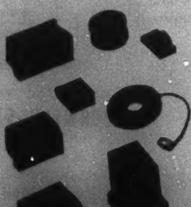
CLUTCH RINGS　CHEMICAL CARBONS　FRICTION SEGMENTS
CARBON PILES (Voltage regulator discs)　CONTACTS
GLASS MOLDS　SEAL RINGS AND WASHERS (for gas or liquid)
DASH POT PLUNGERS　BEARING MATERIALS　ELECTROLYTIC ANODES
RESISTANCE WELDING & BRAZING TIPS . . . ***and many more***

HERE'S REAL MOLD and DIE ECONOMY ◀ FOR MANY APPLICATIONS

Carbon and graphite have interesting properties for foundry use as well as for molds and dies in such diverse fields as powdered metallurgy, glass manufacture and rail bonding. In foundry work, for instance, their high heat capacity and conductivity make carbon and graphite highly efficient as chill materials for ferrous and non-ferrous metals. In powder metallurgy, they maintain their strength under pressure at elevated temperatures much better than other materials and hence are widely used as molds for hot pressing tungsten carbide base tool materials. In still other instances, the simplicity of forming accurate carbon or graphite molds and dies lends itself to real economy. Write for suggestions based on your particular molding problem.

NON-WELDING, ARC RESISTANT ELECTRICAL CONTACTS ▶

The non-welding, arc-resisting and non-filming characteristics of Stackpole carbon-graphite contacts make them eminently suited for many applications including use as arcing tips, distributor buttons and contactor and relay contacts. Used in combination with silver or copper, they are highly effective in circuit breakers, Diesel starting switches, relays and practically every type of contact application. Stackpole engineers welcome the opportunity to recommend standard or special contact grades for specific equipment.



WRITE FOR THIS HANDY DATA BOOKLET

Besides describing dozens of specialties, this Stackpole Booklet 40 contains a wealth of practical data on the characteristics of carbon and graphite and their engineering applications.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

The Pacific Electric Mfg. Corporation

announces
the availability of

TYPE RHE OIL CIRCUIT BREAKERS

3-cycle interrupting time
20- to 50-cycle field-adjustable reclosing time

Kv	Amp to	Interrupting Kva to
115	1200	5,000,000
138	1200	5,000,000
161	1200	7,500,000
196/230	1200	10,000,000
230	1200	10,000,000

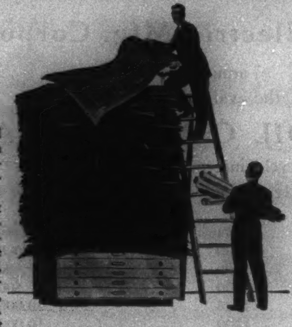
Deliveries have now started in the 230-kv ratings of which orders for eighteen 3-pole units are now in process of manufacture.

These circuit breakers embody in advanced form the design elements of the prototype RHE circuit breakers which at the Grand Coulee Tests of June 1948 easily interrupted the entire available short-circuit capacity: 9,600,000 kva at 242 kv, ASA 3-phase basis—said to be the largest fault ever interrupted.

PACIFIC ELECTRIC MFG. CORPORATION
San Francisco 24, California

All These Were Once
DUST COLLECTION PROBLEMS, TOO

48 Carbon Black Plants
203 Metallurgical Installations
205 Acid Plants • 40 Paper Mills
270 Detarring Installations
216 Power Stations
73 Steel Plants • 99 Oil Refineries
and Miscellaneous Installations



Your electrical precipitator installation will be individually engineered...and based on the Research Corporation's *experience* graphically shown by that towering pile of thousands of blue prints.

This knowledge is a valuable asset that will help Research engineers to "tailor-make" your Cottrell installation. For example, they can more quickly determine the right answers to such variables as the size, shape and type of both discharge and collecting electrodes, their relative spacing, flue arrangements and many other factors. At Research you can count on *profitable solutions to individual problems.*

Research Corporation Cottrells can be made as efficient as you desire. They can collect 95% to over 99% of all solid or liquid particles suspended in gas entering equipment. Write for free booklet giving valuable data. RC-121

Typical One Day Collections

- **250 TONS OF FLY ASH**
- **5500 POUNDS OF CONCENTRATED SULPHURIC ACID**
- **6 TONS OF SODA SALTS AT PAPER MILL**

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Very Low Frequencies covered by the . . .

STODDART NM-10A
RADIO INTERFERENCE AND FIELD INTENSITY METER

- MEASURES radiated and conducted signals, including pulse or random interference.
- RANGE—14 kc to 250 kc.
- SENSITIVITY — Field strength using rod antennas one microvolt-per-meter to 2 volts-per-meter. Field strength using shielded loop antennas 10 microvolts-per-meter to 100 volts-per-meter. As a two-terminal voltmeter, either balanced or unbalanced, one microvolt to one volt.
- READS directly in microvolts and db.
- A.C. POWER SUPPLY REQUIREMENTS 105 to 125 volts or 210 to 250 volts A.C. Single phase source may be ANY FREQUENCY BETWEEN 50 CPS AND 1600 CPS. No shock hazard.
- GRAPHIC RECORDER included with versatile complement of accessories.

Write for complete technical data

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Washington 6, D. C.
Phone Hudson 7313

(Continued from page 26A)

arc-extinguishing auxiliary switch. The unit is available with or without the auxiliary switch in two voltage ratings: 15,000 and 7,500 volts. Further details may be obtained from the company.

Vibrator Converters. Cornell-Dubilier has announced a new line of vibrator converters, designed specifically for railroad communications and power conversion requirements. They are available in models for operation on 32, 64, and 120 volts direct current input. All units have an output rating of 115 volts alternate current, 60 cycles at 375 volt-amperes. No lubrication is required, a standby vibrator automatically picks up load at the end of service vibrator life, unskilled personnel can remove or install replacement vibrators, and there is up to 60 per cent reduction in initial cost. Further engineering data may be obtained from the Indianapolis Division, Cornell-Dubilier Electric Corporation, 2900 Columbia Avenue, Indianapolis, Ind.

Three-Inch Portable Oscillograph. The Allen B. Du Mont Laboratories, Inc., Clifton, N. J., have recently brought out a 3-inch cathode-ray oscillograph, Type 292, which combines features previously found only in 5-inch models. Increased portability is largely due to the new Du Mont Type *3RP-A* 3-inch cathode-ray tube which is only 9½ inches long. The instrument weighs only 21 pounds. Input signals of 0.4 rms volt and 0.56 rms volt produce 1-inch deflection on vertical and horizontal axes, respectively. *X*-axis and *Y*-axis amplifiers supply their respective pairs of deflection plates with voltages that are 180 degrees out of phase, which virtually eliminates astigmatic defocusing and trapezoidal distortion. The gas-triode linear time-base generator provides recurrent sweep frequencies from 8 to 30,000 cycles per second, synchronized with either the vertical amplifier or some external source. Additional data may be obtained from the company.

Square D Developments. The Square D Company's Kollsman Instrument Division has developed a Kollsman altitude controller, an aneroid actuated mechanism, which controls the automatic pilot when corrections in the flight path are required to maintain a selected altitude. This is accomplished by the use of the recently developed Kollsman Synchrotel which is connected to the altitude controller through a d-c magnetic clutch. When the magnetic clutch is engaged, the controller, overriding the gyroscope, compels the autopilot to hold a constant altitude. Electrical output of the controller at sea level is compatible with operating requirements of various types of automatic pilots. The device can be constructed so that the output in millivolts per foot can either be held constant for any altitude up to 50,000 feet, or made to drop off progressively. Additional information is available from the Kollsman Instrument Division of Square D Company, 80-08

(Continued on page 36A)

NOW for the first time...

...A HIGH-VOLTAGE INSULATION WITH ALL THE PROPERTIES NECESSARY FOR TROUBLE-FREE SERVICE UNDER ALL OPERATING CONDITIONS...

LOW WATER ABSORPTION

OZONE RESISTANCE

RESISTANCE TO HEAT AND AGING

SIMPLEX-ANHYDREX XX

Here at last, in the new Anhydrex XX insulation, is the combination that assures dependable, low-cost cable performance under all conditions of high-voltage service. And in Anhydrex XX none of the effectiveness of one property has been sacrificed to gain the others.

Aged in an air oven for sixteen weeks at the grueling temperature of 250 F. (121 C.) Anhydrex XX remained rubber-like in quality and appearance, was still suitable for continued use. It retained approximately half of its tensile strength, nearly two-thirds its elongation. Most important of all, its rate of deterioration after the first few weeks was very slight, indicating exceptional stability and long life.

Ordinary oil base and heat-resistant compounds could not match this performance. Inside of only three weeks both had become brittle and, upon bending, immediately cracked and crumbled.

Aged at the same high temperature for seven days, Anhydrex XX was immersed for a week in distilled water at 158 F. (70 C.). It would not absorb more than 15 mg. per square inch of exposed surface. It was exposed to .03% ozone for four hours yet would not crack when bent.

Anhydrex XX is the only insulation that provides this valuable combination. To enable you to determine fully the effectiveness and stability of these properties even after years of service, we have drawn up an ironclad specification for Anhydrex XX. We will be glad to send you a copy on request. Just ask for Specification 1685.

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REVOLUTIONARY PRINCIPLE OF REACTOR SWITCHING

An entirely new and revolutionary principle of reactor switching is used in the Moloney Load Tap Changers. Through its use, there is no Switching Reactor (Preventive Auto) loss on half of the operating positions when operating half cycling, and no loss on *any* operating position when operating full cycling. Diagram shows how reactor halves are by-passed when Tap Selector Switch is in any "on contact" position. Elimination of reactor loss results in tangible savings in operating costs.

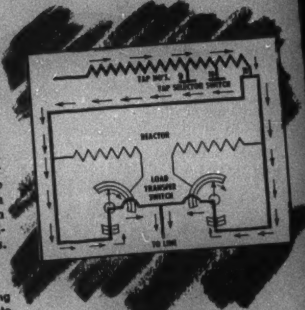


Diagram shows how Switching Reactor is by-passed to eliminate its loss.

NO ARCING ON TAP SELECTOR SWITCH

The Tap Selector Switch on Moloney Load Tap Changers does not have to perform the dual function of breaking current and changing taps. A separate Load Transfer Switch makes and breaks the circuit, eliminating all arcing duty from the Tap Selector Switch, and making it possible to use longer arc clearances and highly accelerated breaker opening and closing speeds, with consequent increase in interrupting capacity.

Load Transfer Switch at upper left. Reversing Switch at upper right. Tap Selector Switch at bottom.

COMBINED SPRING-ACCELERATED AND DIRECT DRIVE LOAD SWITCHING

Highly accelerated opening and closing speeds are used on the Load Transfer Switches to minimize arc erosion. These high speeds are obtained through the use of accelerating springs. Although the spring materials used and stresses at which they are operated are such that almost indefinite life is assured, in event of spring failure, the tap changer will continue to operate in direct drive. This system combines the best features of spring drives and direct drives.

Load Transfer Switch, right, is driven by accelerating spring arrangement to provide highly accelerated opening and closing speeds.

Load Tap Changer!

MOLONEY QUALITY IS NOW AVAILABLE IN AUTOMATIC STEP VOLTAGE REGULATORS, REGULATING TRANSFORMERS AND LOAD RATIO CONTROL TRANSFORMERS

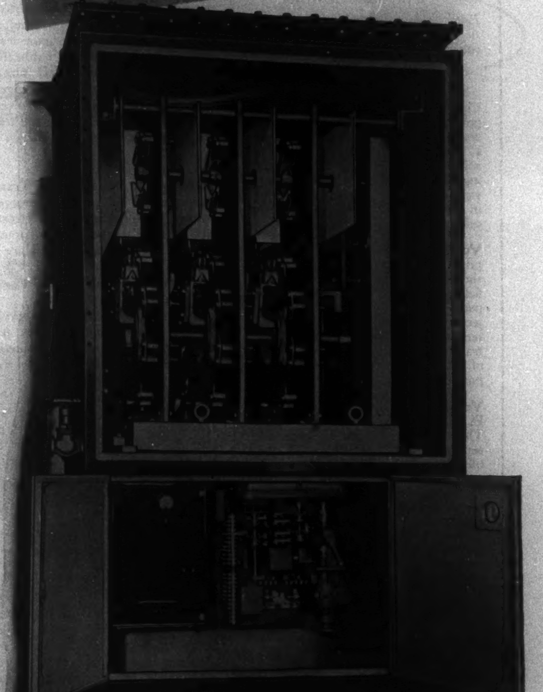
DESIGN CHARACTERISTICS AND RATING

Moloney Load Tap Changers are designed to operate satisfactorily under the following operating contingencies:

1. Continuous full-load operation at any point in its operating cycle
2. Short circuits or grounds on systems to which it may be connected where the current may reach 25 times normal rating for 2 seconds
3. Recurrent short-time overloads or emergency short-time overloads as defined in the American Standards Association Guide for Operation of Transformers and Regulators, *making it possible to take full advantage of the full transformer capacity following partially loaded conditions or during times of low ambient temperature*
4. Reduction of control voltage up to 25% with sufficient torque for tap changer operation still developed by driving motor
5. Impulse, surge or transient voltages incidental to the operation of transformers, series transformers, or reactors

FEATURES

1. No reactor loss or voltage drop on full cycling positions
2. No arcing duty imposed on Tap Selector Switch
3. Longer arc clearances for load switching
4. High speed "make" and "break" on load switching with minimum shock from acceleration or deceleration of inertia load of parts
5. Combination spring-accelerated and direct drive
6. Low contact maintenance cost
7. Special arcing tips provided on Load Transfer Switch contacts
8. Contact materials selected to minimize wear from friction
9. Position indicating, pilot switching, and mechanical drive limit equipment are solidly tied in with those parts requiring definite timing
10. Minimum space requirement, at high dielectric level, through the use of high insulating strength materials as combination mechanical supports and barriers between phases
11. Melamine bonded surfaces used in areas subjected to arcing or arc gases
12. All insulating surfaces are mounted in a vertical plane



New Moloney three-phase Load Tap Changer with automatic controls. Top assembly contains Tap Selector Switch, Load Transfer Switches and Reversing Switch. Motor drive and auxiliary equipment are at lower right. Automatic controls are at lower left. Moloney Automatic Control equipment features a super-sensitive voltage regulating relay and an electronic time delay circuit. A complete line of remote-manual and automatic controls and associated equipment is available.

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Volume II—COMMUNICATION—ELECTRONICS will be ready soon. The two volumes can be purchased separately or as a set. Together, they offer complete coverage of the electrical engineering field. Separately they make convenient individual working tools for those with specialized interests in the field. They are part of the Wiley Engineering Handbook Series.

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(Continued from page 32A)

45th Avenue, Elmhurst, N. Y. The company has also announced a new line of a-c magnetic starters and contactors, designed to conform to latest National Electrical Manufacturers Association Standards for Industrial Control. Standardized wiring and mounting dimensions have been adopted to simplify engineering, installation, and maintenance of machine controls. Further details are contained in Bulletin *8536*, which may be had by writing the Square D Company, Industrial Controller Division, 4041 North Richards Street, Milwaukee 12, Wis.

Oscillator. Measurements Corporation, 116 Monroe Street, Boonton, N. J., has produced a new Model *112* ultrahigh frequency oscillator, covering the frequency range of 300 megacycles to 1,000 megacycles. Frequency calibration is accurate to ±0.5 per cent. The oscillator has a maximum output voltage, varying with frequency, between 0.3 volt and 2 volts. Any other data desired may be obtained from the company.

Electrostatic Precipitation Transformer. Transformers for use as a source of high voltage in equipment for electrostatic precipitation of smoke, metals, or other materials from gaseous mixtures are available from Westinghouse Electric Corporation. The new transformers are oil insulated and hermetically sealed. Radio interference and corona are kept to low levels by improved high-voltage bushings treated at critical points with a semi-conducting glaze. Visual corona is eliminated up to 85 kilovolts by this method. Precipitation transformers are available in 5, 7½, 10, 15, and 25 kva sizes for 60,000-volt or 75,000-volt operation at 60 cycles. Others are available for operation at 25 cycles. The Westinghouse Electric Corporation, 306 Fourth Avenue, Pittsburgh 30, Pa., will supply any further details.

TRADE LITERATURE

Locke RM Handylog. Repetitive Manufacture (*RM*) is a program designed to help reduce the installed cost per kilowatt on line and station equipment. The second edition of the Locke *RM* Handylog describes, in 99 pages, up to 95 per cent of the items of power insulators, suspension hardware and pole line hardware most frequently used on power transmission, distribution lines, and stations. Copies of the spiral-bound catalog are available upon request to Locke Inc., P. O. Box 57, Baltimore 3, Md.

Weston Modernization Data. Modernization data is now available for owners of the earlier types of the Weston Model *798* Tubecheckers. All former types may be modified to include the latest tube calibration data. Conversion itself is not too difficult, and can be made easily with simple tools. It is not necessary to return the

(Continued on page 40A)

American Standard LETTER SYMBOLS for ELECTRICAL QUANTITIES

This new American Standard (Z10.5—June 1949) prepared by a subcommittee of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering, is a revision of ASA Z10g1 and AIEE 17g1.

General principles of letter symbol standardization, a typographical notation for distinguishing, in the equations of the printed page, between the symbols for scalar, complex (phasor), and vector quantities are given, as well as tabulations of the symbols in alphabetical order of the names of quantities, English letter symbols, and Greek letter symbols.

Price: $0.60; 50 per cent discount to AIEE members on single copies.

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115 volt primary to 6 volt secondary
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230 volt primary to 115 volt secondary
460 volt primary to 115 volt secondary
230/460 volt primary to 115 volt secondary
575 volt primary to 115 volt secondary

Other designs are illustrated in Control Catalog Bulletin C176.

ACME ELECTRIC CORPORATION
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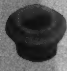
Acme Electric



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American Standard for
ELECTRICAL INDICATING INSTRUMENTS

Part 1 Switchboard and Panel Instruments

C39.1-1949 is a revision of the first American Standard on Electrical Indicating Measuring Instruments, C39.1-1938, approved by the American Standards Association in July, 1938. This new specification is intended to assure that instruments conforming to it will be satisfactory for general industrial use. Price: $1.50; $0.75 to AIEE members for single copies.

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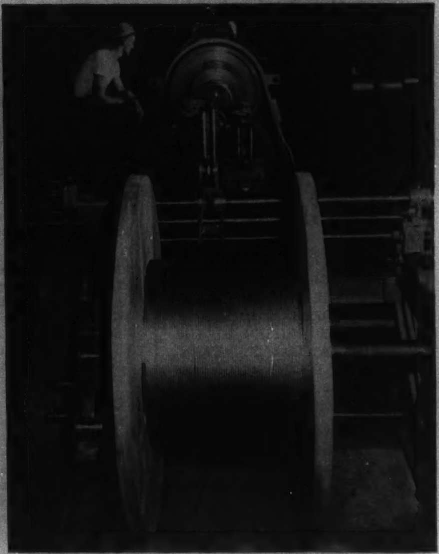

ROD IS DRAWN into wire on the most modern equipment in the electrical conductor industry. High speed cable stranders, manned by skilled personnel, produce the finished conductor, which has been tested at every step by modern methods and equipment. Result of this completely integrated production control is pictured above—aluminum conductor of unsurpassed quality!

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PROFESSIONAL
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JUNIOR
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THIS 56-PAGE PUBLICATION, ISSUED BY THE ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT, WAS WRITTEN BY THE LATE DR. WILLIAM E. WICKENDEN, AND EDITED BY G. ROSS HENNINGER.

The book seeks to give the young engineering graduate a sense of professional values in chapters on engineering origins and professional relationships. Full treatment is given to the practical side of getting an engineering job and of advancing in the profession. Also included is the Council's credo "Faith of the Engineer," a self-appraisal questionnaire, and the Canon of Ethics for Engineers.

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(*Continued from page 36A*)

checker to the factory. This conversion is advisable for Weston Model *798* Types *3*, *3A*, *4*, *4A*, *5*, *5A*, *6* and *6A* Tubecheckers. Modernization data can be obtained from the Weston Electrical Instrument Corporation at 614 Frelinghuysen Avenue, Newark 5, N. J.

Industrial Electronic Coatings. To acquaint engineers and other professional workers in the electrical industry with the possibilities and applications of conducting, resistance, and magnetic paints in their work, the Microcircuits Company, New Buffalo, Mich., has issued a pamphlet, "Industrial Electronic Coatings," which is available upon request to the company.

Matthews GOABS. The W. N. Matthews Corporation has introduced a new line of gang operated air break switches, known as *GOABS*, which are completely described in their bulletin *601*. Copies may be obtained by writing to the company at 3850 Delor Street, St. Louis 16, Mo.

Cable Selection. The Construction Materials Department, General Electric Company, Bridgeport, Conn., has issued a new booklet, "Selection of Proper Cable Sizes," which deals with the method of determining cables and cable sizes of asbestos-varnished cambric cables, types *AVA*, *AVB*, and *AVL*. Step-by-step instruction is given on figuring load current, voltage drop, cables, and cable sizes for both lighting and motor loads. Copies of this publication, number *19-269*, are available from General Electric.

Transformer Reference Catalog. In addition to providing detailed specifications on air cooled transformers from 1/10 kva to 50 kva, catalog *AC 178* issued by Acme Electric Corporation, Cuba, N. Y., describes improvements made recently in design and construction. Also included are wiring diagrams showing how air cooled transformers may be used to eliminate independent wiring for power and light; distribution of power at high voltage; operation of 115-volt equipment from power circuits; providing for three wire single phase circuits from a two wire source, and boosting voltage in circuits subject to voltage drop. Copies are available from Acme.

McGraw-Hill Books Catalog. The 1949 issue of the McGraw-Hill Books catalog with a complete subjects index may be obtained by writing to the McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y.

Hot Spots Tape. An electrical tape (number *27*) that will stand temperatures up to 300 degrees Fahrenheit is described in a four-page brochure available from the Minnesota Mining and Manufacturing Company, 900 Fauquier Street, St. Paul 6, Minn. Tape samples are also available.

Report on
GUIDING PRINCIPLES for DIELECTRIC TESTS

(Published for comment and criticism)

The service record of electric equipment depends largely upon the performance of its insulation, and it has long been the practice to test new insulation at a voltage appreciably greater than its rated operating voltage. Dielectric test voltages should be chosen to result in good operating performance and satisfactory life. The purpose of this report (AIEE No. 51, September, 1949) therefore, is (1) to present a survey of the overvoltages encountered in service, (2) to review existing test values and practices in present standards, (3) to propose guiding principles for the selection of dielectric test values, and (4) to investigate other types of testing to determine their latent usefulness and the desirability of standardization

◆ ◆ ◆

Proposed Standard for
AUTOMATIC CIRCUIT RECLOSERS for
DISTRIBUTION SYSTEMS

(Proposed for one year trial use)

This standard (AIEE No. 50, September, 1949) applies to all single or multipole a-c automatic circuit reclosers rated from 1,500 to 15,000 volts. The work of preparing this standard was carried out by the Working Group on Automatic Circuit Reclosers under the Circuit Breaker Subcommittee of the AIEE Committee on Switchgear.

There is no charge for these publications. Orders should be sent to:

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Shorter—Nearly 5" shorter than the 16AP4, the new, wide-angle RCA-16GP4 permits reduction in depth of chassis and cabinet, and thus makes possible greater compactness in receiver styling. In addition, the 16GP4 permits economies in tube stocking, packaging, and shipping.

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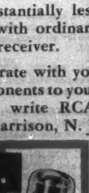

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Positions Wanted

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ELECTRICAL ENGINEER, BSEE, also BBA degree, one year graduate study electrical transmission and distribution, good practical knowledge of industrial electronics, some teaching experience, two years experience industrial electronic maintenance, desire employment in public utility, manufacturing, or teaching field. Age 26, married, location Southwest. Address: Box 858, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ENGINEERS BSEE 1946 from Purdue University with majors in electronics & mathematics. Age 23. Married. Three years experience with Navy Supply Corps (Lt.jg.). Member Eta Kappa Nu. Desire research and/or development anywhere in U. S. Address: Box 859, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ELECTRICAL ENGINEER, June 1949 grad., desires traveling position as service or application engineer for an electrical equipment or instrument manufacturer 2½ yrs. previous machine shop inspection experience. Presently employed. Age 25, single, veteran. Address: Box 862, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRONICS ENGINEER, B.S.E.E., M.S.E.E. in June 1949, age 22, single. Desires position leading toward research or development work. Address: Box 863, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

RECENT GRADUATE, married, 29 yrs. old. BS in EE, excellent Military and Scholastic record. Desires work in electrical field. Locate anywhere. Address: Box 864, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER, B.S.E.E., Mich. State College 1942, age 29, married. 3 yrs. exp. in industrial maintenance. Service schooling in electronics at Harvard University. Would like position in industrial maintenance or sales of electrical equipment. Address: Box 867, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ELECTRONICS ENGINEER—Well known, 40 year-old manufacturer of electrical and electronic instruments wants research engineer experienced in design of radio electronic apparatus at high radio frequencies, for the development of military and civilian test equipment. Address: Box 697, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

PROFESSOR OF COMMUNICATIONS ENGINEERING needed for Fall 1949 by Southeastern University. Will be in charge of graduate work and research activities. $6000 for nine months with extra income for summer teaching. Must have Ph.D. or D.Sc. degree. Address: Box 735, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

MECHANICAL & ELECTRICAL ENGINEER—Excellent opportunity for young man with approximately seven years experience in design, specifications and supervision of the mechanical and electrical phases of building construction, with particular emphasis on school and institutional work. Full partnership offered for right man in established engineering office. Location: New England. Address: Box 865, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED: Experienced electrical engineer with ten years in power, not over 45, for responsible position with Mining Company in Bolivia. Salary $5,000 up depending on experience. Address: Box 866, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

RESISTANCE WELDING ENGINEER—Progressive mid-western manufacturer of resistance welding equipment has opening for good classical and practical engineer. Must have degree, several years experience, and ability to carry on original independent development. Possibility of quick promotion to Chief Engineer. State full education, experience, and salary expected. Address: Box 868, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ELEC ENGR, B.E.E., 1949, Cornell; 21, single; desires pos with elec mfgr, util or constr firm. Majored in pwr generation, des and trans. E-502.

ELEC ENGR, B.S.E.E., June 1949, Univ of Pittsburgh; 24, single; Class B amateur license; desires pos in pwr or electronics. Location and salary secondary. E-503.

EXEC ENGR, B.S.E.E., 1932, W.P.I.; 40, married; 16 yrs elec and mech indus exper in des; constr; maint. Desires association with mfg, consulting or contracting organization. Location immaterial. E-504.

ELEC ENGR, B.S.E.E., 1948; 27, single; 1 yr airp radio and radar eqpt installation. Desires employment in S. A., pref in lighting or pwr. Will consider other foreign employment. E-505.

ELEC ENGR, B.S.E.E., June 1949; majored in pwr generation and trans; 25, married; Desires pos in pwr, distr or trans. Location immaterial. E-506.

ELEC ENGR, BSEE; rec grad B.A. Journalism; 33, married; 3½ yrs Navy elect exper; desires pos Northeast area combining both fields. Progressive organization preferred. E-507.

ELEC ENGR, B.E.E.; 28, married; 15 mos G. E., Test engr; 3½ yrs machinist, parts inspector; Tau Beta Pi, Eta Kappa Nu; desires methods and process engg. Prefers metro New York or northern New Jersey. E-508.

ELEC ENGR, B.E.E., Sept. 1949; 25, single; Eta Kappa Nu. Desires pos as instructor in univ in south or southwest; would like opportunity to obtain M.S. E-509.

Positions Available

ELECTRICAL ENGINEER, graduate, with at least five years' power and transmission design, operating and planning experience, to make surveys of utility and industrial power facilities and submit comprehensive reports. Salary, $6000 a year. Location, East. Y-2768.

MANAGER for a group of utility properties in the electric, gas, telephone and water fields. Must have experience in all phases of utility management, and ability to plan future expansion of gas, electric and telephone business, and economics in present operations. Salary, $6500–$8000 a year, to start. Location, Southwest. Y-2781.

ELECTRICAL ENGINEER, young, graduate, with instrument background, some writing or teaching experience and some work with methods. After training, will be required to go about the country gathering information from manufacturers which would be transformed to simplified instructional material. Isometric or perspective training would be especially helpful. Salary, $4500–$5000 a year. Headquarters, New York, N. Y. Y-2866.

COMMERCIAL ENGINEER, 30–35, electrical graduate, or mechanical graduate with equivalent electrical knowledge from training and experience, with field sales service experience, including installation and service of products, repairs, engineering changes, etc. After two or three months sales training, will be responsible for technical sales correspondence, estimating for pricing and for quotations to customers, preparing sales data for use by sales, advertising or service departments, etc. Salary open. Location, Connecticut. Y-2919.

RELAY ENGINEER with broad knowledge of relaying and control in connection with large power and lighting generating and transmission systems. Must have at least five years' experience in planning, coordinating, testing and repair of modern power system relaying. Location, Southwest. Y-2946—R-6023.

TELEPHONE DESIGN ENGINEER, 30–50, with ten to fifteen years' recent, fully qualified experience as a telephone design engineer, preferably electrical graduate. Will have complete charge of department that will design telephone systems of all types. Will supervise engineers in this department in the design and construction of telephone systems. Salary, $6000–$7000 a year. Location, North Carolina. Y-2983.

ELECTRICAL ENGINEERS, young, for training positions covering work in overhead and underground electric transmission, distribution and street lighting systems. Some experience in this field desirable; or an interest in the work as indicated by college courses. Salary, $3000–$3380 a year. Location, Maryland. Y-2985.

EXECUTIVE ASSISTANT, 30–40, mechanical or electrical graduate, who has had a minimum of five years' operating experience with electric public utility. Personnel experience very desirable, as successful applicant will also head this department. Salary, $7000–$9000 a year. Location, Southwest. Y-2988.

ENGINEERS. (a) Senior Electrical Engineers with five or more years' experience, to do advanced development work on television receivers. (b) Junior Electrical Engineers with three or four years' experience on development work on television receivers. Location, upstate New York. Y-3022.

ASSISTANT PROFESSOR, graduate, to teach electrical engineering. Should have M.S. in electrical engineering and some experience in industry or teaching. Will teach electrical engineering courses for non-electrical students. Prefer applicant qualified in mechanics. Position starts July 1, 1950. Salary, $3600–$4000 for eleven months. Location, Colorado. Y-3037.

ENGINEER, B.S. in electrical or mechanical engineering, with at least ten years' experience, preferably in the testing of home appliances, and several years' experience in a supervisory capacity, to test as well as supervise and direct the testing of home appliances such as washing machines, refrigerators, vacuum cleaners, etc., to prepare test methods, apparatus, reports, etc., and to supervise and review their preparation. Salary, $6240 a year. Location, New York, N. Y. Y-3038.

ELECTRICAL AND MECHANICAL ENGINEERS with degree in electrical or mechanical engineering, and at least three years' experience in steam-electric generating plant design, with thorough understanding of the factors determining proper design of modern medium pressure and temperature installations. Salary, $5400 a year to start. Occasional field trips. Location, Washington, D. C. Y-3045.

ENGINEERS. (a) Assistant General Manager, 38–45, electrical graduate, or mechanical with additional studies in business administration. Should have experience in metal industry, technical precision, electrical or

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1-50

mechanical machinery or instruments. Experience should include organization and administration including investigations, analysis and coordination of engineering, manufacturing and sales, budgets and cost reduction. (b) Sales Office Supervisor 30–40, electrical graduate, or mechanical with equivalent electrical knowledge. Experience in the metal industry in the sale and service of electrical and mechanical machinery, equipment or instruments, including sales office supervision, sales engineering. Limited traveling. Salaries open. Location, Connecticut. Y-3049.

PRODUCT ENGINEER, 30–40, mechanical or electrical graduate, with design and development experience covering pumps, compressors, motors and accessories for development of new uses for non-ferrous materials. Salary, $5000–$6000 a year. Location, Michigan. Y-3053.

DESIGN-DEVELOPMENT ENGINEER, graduate electrical or mechanical, about 40; substantial experience with industrial and recording instruments. Able to take responsible charge of project department, and eventually to take over position of chief engineer for a manufacturing company. Salary, $6000 a year. Location, Chicago, Illinois. R-6005.

CHIEF ELECTRICAL ENGINEER, graduate, 40–45; minimum of fifteen years' experience in the design of central station power plants (steam or electrical); must have strong technical background and be completely informed regarding all design details as encountered in a consulting engineering office. Salary, $9000 a year. Location, Chicago, Illinois. R-6039.

ENGINEERS. (a) Designer, graduate electrical engineer, 35–40, with considerable experience on mine or coal preparation plant equipment (mill machinery, motors, remote control, etc.) involving D.C. for underground installations and A.C. for both ground installations. Will be required to prepare and write requisitions for materials, make diagrammatic sketches, estimate, wire, supplies and equipment from specifications. Must understand use and distribution of D.C. With consulting engineer firm. Salary open. (b) Structural Engineers, graduate civil, 35–40, with substantial experience on concrete and steel as applied to coal preparation plants. Salary open. Locations, Chicago. R-6059.

DESIGNER (electronics), graduate in electrical engineering or physics, experienced in design of electronic circuits. Will work on custom design and building of electronic equipment for special industrial applications and assist in guidance of recently graduated engineers; able to translate theoretical problems into practical execution; promise of supervisory duties and rapid advancement. Salary open. Location, Michigan. R-6081.

RESEARCH AND DEVELOPMENT ENGINEER, B.S. in E.E., about 25. Two years' experience with electronics, low frequencies. Knowledge of aircraft instruments. Small company; opportunity for diversified experience. Salary, $4420 a year. Location, Chicago, Illinois. R-6085.

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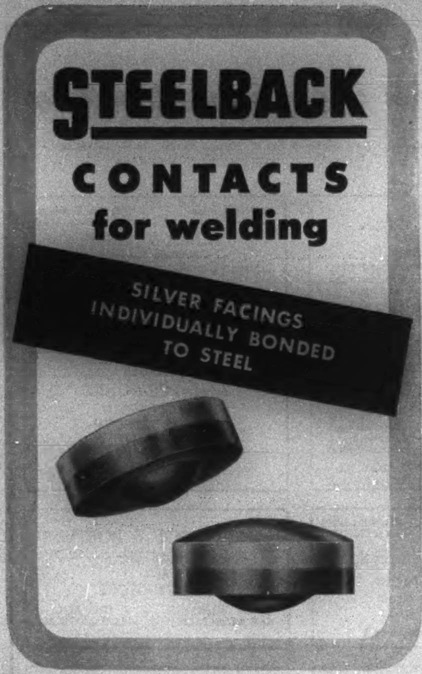

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MICROAMPERES, DC: 100
AMPERES, DC: 10
DECIBELS: (5 ranges)—12 to +55 DB
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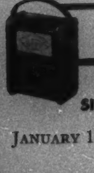

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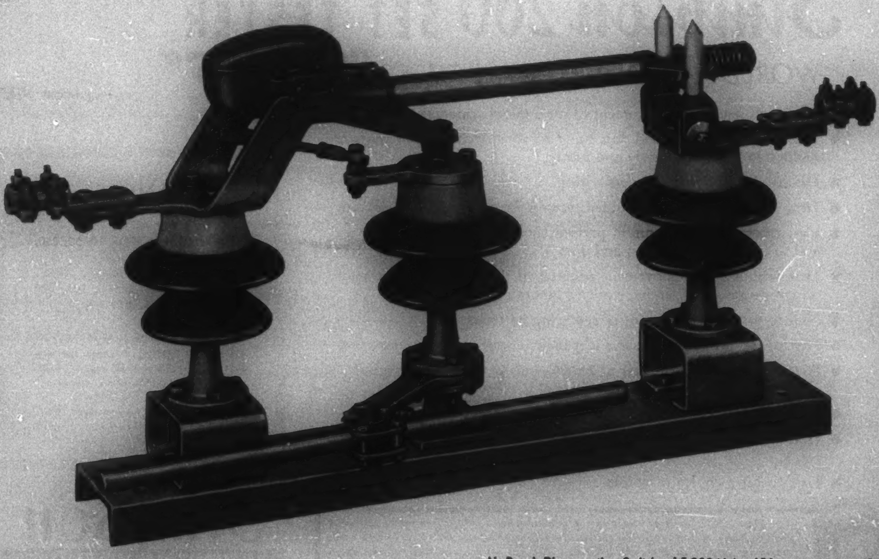
Tests made in our laboratory under severe icing conditions show the switch illustrated below, closed (left) and after opening (right). Ice was over 1″ thick. Only 450 inch pounds were required to open switch.



Air Break Disconnecting Switch—15,000 Volts, 600 Amperes, Type 0-2
Vertical Break, Three Pole, Single Throw, Group Operated
SILVER TO SILVER CONTACTS

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- It has a panel-mounted d-c zero-center galvanometer for d-c null indication
- It is very simple to operate

RANGES

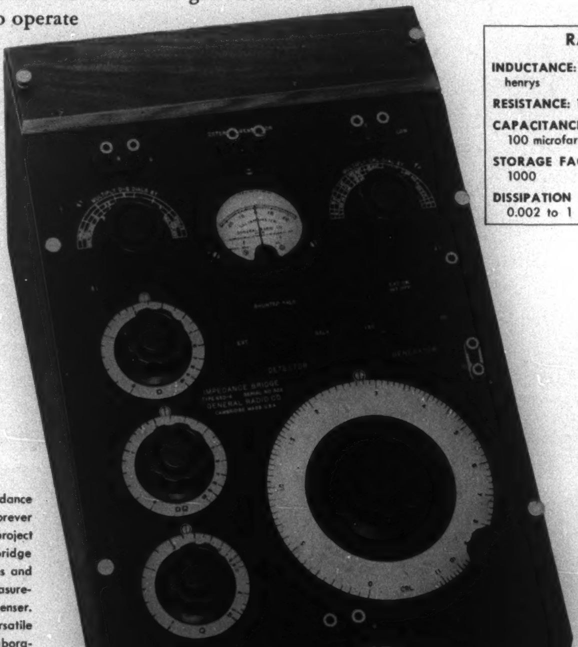
INDUCTANCE: 1 microhenry to 100 henrys

RESISTANCE: 1 milliohm to 1 megohm

CAPACITANCE: 1 micromicrofarad to 100 microfarads

STORAGE FACTOR (X/R: 0.02 to 1000

DISSIPATION FACTOR (R/X): 0.002 to 1



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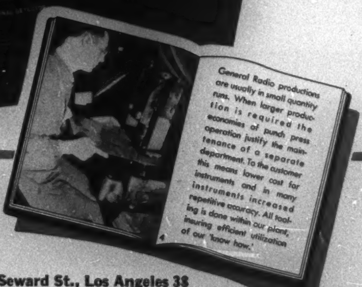

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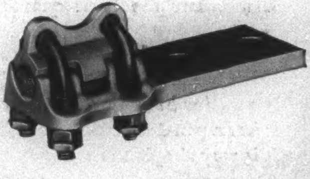

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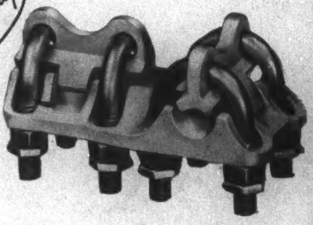
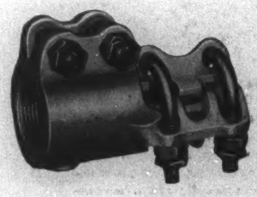


Station Tee Connector



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